PATHWAYS IN SCIENCE
LEARNING ABOUT OUR WORLD

COMPLIMENTARY
PROFESSIONAL COPY

CRAIG AND CONDRY

A picture of a summer scene. In it you will find some of the things that you will read about in these stories. See how many different things you can find

PATHWAYS · IN · SCIENCE · V
A COURSE FOR ELEMENTARY SCHOOLS

Learning About Our World

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Preface

"Learning About Our World" is the fifth book in the Pathways in Science series. It is planned and written in order to interest boys and girls in the world in which they live. It aims to acquaint children with the things they see around them, and to give them some scientific knowledge about these things.

The content of the text is organized in twelve units. Each unit presents a series of problems about some type of science learning that should receive special study and emphasis before children leave the elementary school.

There are units in this book about seasonal changes, about plants and animals, about the sun, the stars, and the moon, about the weather, water, light, and temperature. Other books of the Pathways in Science series also have units on these subjects. The approach and treatment of the units in "Learning About Our World" are very different from the approach and treatment of these units in the earlier books. The children, without losing interest because of this repetition, gain much additional worth-while information.

In certain units the text deals with the conservation of living things. The place and importance of

birds, mammals, snakes, amphibians, and insects are emphasized. The protection of our wild flowers and forests because of their æsthetic and economic value is stressed.

Many of the units in the book afforded an opportune place in which to develop some of the underlying principles of the health and care of the body.

Some of the actual experiences that fifth-grade children have had in observing the spring and fall migration of birds, in experimenting with plants, in watching the development of amphibians, moths, and butterflies, and in working with magnets and electricity will be found in the book.

Special care was taken to keep the expression of the content of this text within the comprehension and reading ability of the average fifth-grade child, by checking the vocabulary with the Buckingham-Dolch Word List and by keeping the sentence structure simple.

"Learning About Our World" is accompanied by a manual for the use of the teacher. This manual will be found most valuable in guiding teachers in the interpretation and presentation of the different problems in the text. Some of the things which it contains are additional information in subject matter for the teacher, additional activities for the children, and a bibliography for the teacher.

The text conforms to the recommendations and the spirit of the Thirty-first Yearbook, Part I, of the National Society for the Study of Education, and the requirements of recent city and state courses of study in elementary science.

To Dr. B. R. Buckingham the authors are especially indebted, and wish to express their appreciation for his guidance. His advice, encouragement, and helpful suggestions made the writing of "Learning About Our World" possible.

For their interest and coöperation in locating and supplying photographs the authors are grateful to the United States Department of Agriculture, Steamboat Inspection Service of the United States Department of Commerce, United States Bureau of Biological Survey, United States Bureau of Entomology, United States Bureau of Mines, United States Forest Service, American Museum of Natural History, Field Museum of Natural History, Lowell Observatory, Mt. Wilson Observatory, Byrd Antarctic Expedition, Wild Flower Preservation Society, Hugh Spencer, W. Lyman Underwood, Cornelia Clarke.

G. S. C.
M. G. C.

Contents

LEARNING ABOUT OUR WORLD

We live on a large ball floating in space. As we look out into this space, we see many different things. We see stars, comets, shooting stars, the sun, and the moon. As we look about on our own world, we see some things which are living, such as plants and animals, and other things, such as mountains, rocks, and rivers, which are not living. About us are many things which have been made by man, such as plows, magnetic compasses, tractors, automobiles, and airplanes. About us are also things which we cannot see, but which we know are there. All these things have interested people. Men have wondered about them, and have asked such questions as these:

What causes the weather?
Why do not all plants die in the winter?
How does light reach the earth from the sun?
How do birds find their way across hundreds of miles of land and sea when they are migrating?
Are there other worlds like ours?

You too have probably asked questions like these.

If you read the stories in this book, you may be helped in answering your questions. You will find them easy to read. Most of the stories have pictures that will help and interest you.

Some of the stories tell about the things that boys and girls found out by experimenting with plants, animals, magnets, and electricity.

You may wish to try these and other experiments. Perhaps you may discover some things that the boys and girls in these stories did not discover. If you continue to experiment and make new discoveries, some day you may be a scientist.

UNIT I

Getting Ready for Winter

1. Why Plants and Animals must get Ready for Winter
2. How Plants get Ready for Winter

GETTING READY FOR WINTER

There are many changes which go on, on the earth. Summer is a season of warmth, while winter is a season of cold. Plants and animals in the great out-of-doors do not live in houses with stoves or furnaces to keep them warm during the cold winter days and nights. In the first three units of this book, we are going to find what they do because of the change of seasons.

What do you think would happen if fathers and mothers did nothing at all to get their homes and themselves ready for winter?

What do you do to get ready for cold weather?

What do plants do to get ready for winter?

What do some animals do to get ready for the cold season?

Problem I · Why Plants and Animals must get Ready for Winter

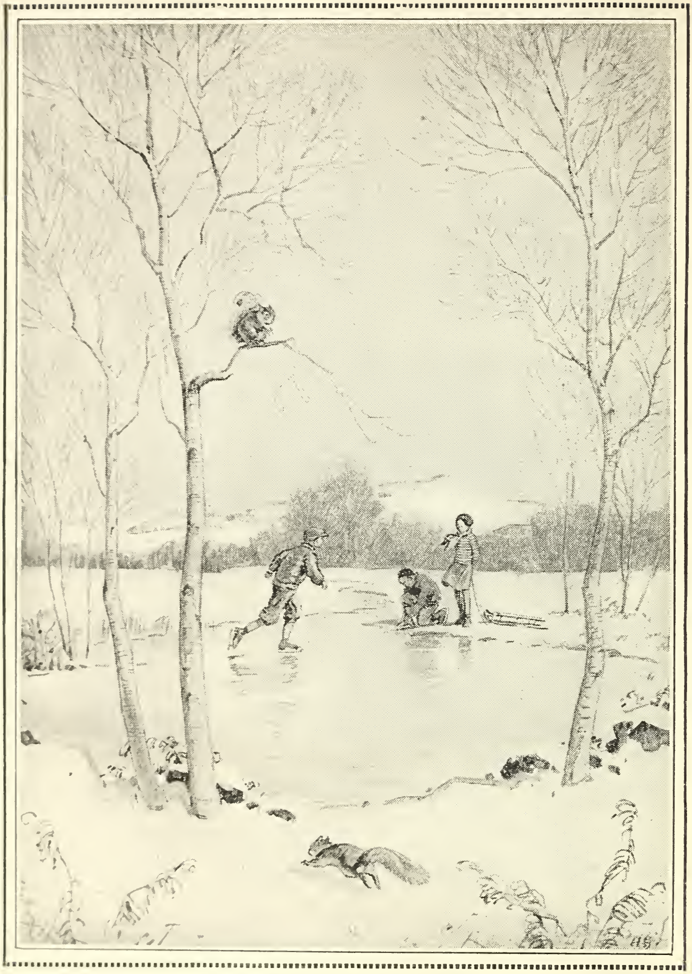
1. Why are some days so long and some so short?
2. Why do we have a change of seasons?
3. Why do some trees lose all their leaves?
4. Why do we have so few birds and animals in winter?

Our seasons change during the year. We do not always have summer. We do not always have winter. Neither do we always have the in-between seasons, spring and autumn.

You have learned that the earth moves around the sun once every year. As it moves, the seasons change. In going around the sun, the earth always travels in the same way. When it reaches a certain place in its path, the days where we live are long. When it reaches a certain other place, the days are short.

When the days are longer than the nights, the sun is high in the sky. It shines on the earth a longer time and gives it more heat. Then we have summer.

When the days are short and the nights are long, the sun is very low in the sky. It shines on the earth only a short time and gives it very little heat. Then we have winter.



A winter scene. What do you see in it that tells you it is a picture of winter? What are the children doing? How does this picture differ from the first picture in this book?

In winter the temperature grows very cold. Water turns into ice and becomes a solid at a temperature of 32° F. ("F." means Fahrenheit, which is one of the scales for measuring temperature.) Plants cannot grow when the water is solid ice. They need liquid water to help them make their food; so they rest during the winter. Many plants cannot grow when the temperature is even below 50° F.

During spring and autumn the earth at any one place gets the same amount of sunlight and heat from the sun. In the spring the days are growing longer. In autumn they are growing shorter. These seasons usually have about the same temperature. But we think of spring as the time when most plants and animals are waking up and getting ready to do things. We think of autumn as the time when they are getting ready for the winter.

The fact that the seasons do change is very important for all living things. When the first cold winds begin to blow, some animals burrow deep in the ground and go to sleep. Some try to get out of the way of the cold winds and go to the south. Some die. But many living things prepare in other ways to live during the cold weather.

Man is able to keep himself warm during the winter. He can build fires. He can put on heavier

and warmer clothing. He can eat food that will make more heat in his body than the food he eats in summer.

Children, and grown-ups too, have different kinds of sports in the winter. They play different games. They don't swim outdoors and go camping and play baseball and football, but they may go skating, coasting, and skiing. And what fun these winter sports are!

Most of the birds get out of the way of the wintry winds. They migrate, or fly to warmer regions.

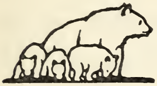
Many of the insects die. Others find sheltered spots. They wrap themselves in some sort of cocoons, or coverings, and rest. A very few insects may migrate to the south.

There are certain animals that cannot stand the cold of winter. They are not able to take the long journeys the birds take; so they go into burrows, or holes under the ground, deep enough to escape freezing. In these they sleep until winter has passed.

The earthworm always lives in a burrow in the ground, but in winter it goes down very deep so that the frost will not reach it.

There is a great difference between the temperature of summer and the temperature of winter. Plants and animals must get ready for this change

in temperature. Unless many of them do the things you have been reading about, they may not be able to live through the long, cold season.



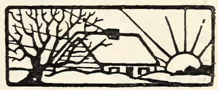
Things to Think About

1. What birds disappear from your home in the autumn and winter?

2. What other animals disappear from your home in the autumn and winter?

3. Why do plants stop growing in the winter?

Things to Do



1. Find out what foods make heat in man's body.

2. Find out the date of our longest day; of our shortest day.

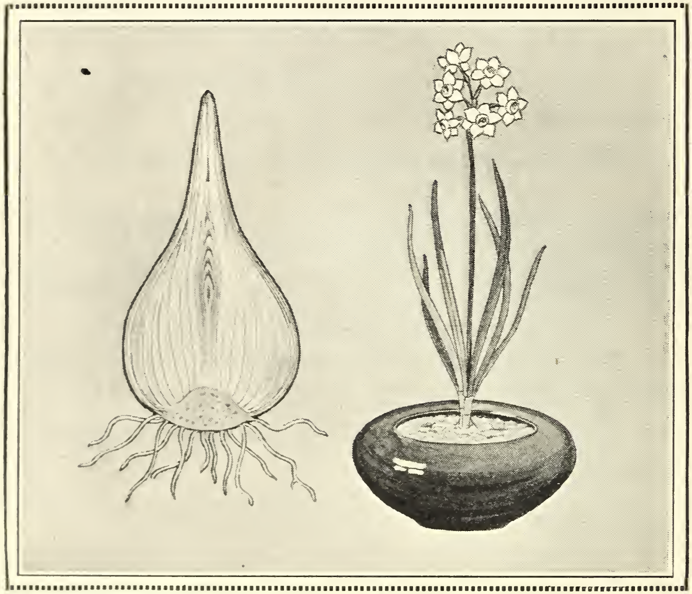
3. As the days grow longer in the spring, notice where the sun rises and where it sets.

4. Notice where the sun is at noon in summer; in winter.

Problem 2 · How Plants get Ready for Winter

1. Where Plants store Food

Some small plants die down to the ground as winter comes. Every leaf and every stem on them



This paper-white narcissus is growing in a bowl of pebbles. Where does the plant get its food? Notice the lengthwise section of the bulb. Can you find the new plant?

dies, but their roots still live in the soil. They have food stored in them for the next year. In the spring new plants may grow from these roots.

Do you know what a bulb is? If you have ever eaten an onion, you have eaten a bulb. Did you or your mother ever plant tulips, hyacinths, or crocuses? Then you planted bulbs. If you put paper-white narcissus or Chinese lilies in bowls of pebbles and water, you plant bulbs. The bulb you ate and the bulbs you planted are little storehouses of food. They are really stems that grow underground. The plants store in the bulbs the food which they make in the summer. These bulbs do not die in the winter. They rest and protect the little plants that they have tucked safely away inside. When the plants begin to grow, they live on the food in the bulbs until they are able to make their own food.

The white, or Irish, potato is not a bulb. It is a different kind of underground stem of the plant and is called a tuber. The "eyes" in the potato are the buds for the new plant. When potatoes are planted, they are cut into pieces so that there are one or two eyes in each piece. These pieces are planted, and the new plant lives on the food stored in the potato until it can make food for itself. Of course you have eaten carrots, turnips, and beets. These are neither bulbs nor tubers. They are the roots of small plants. They grow thick and solid because of the food that is stored in them.

How a maple tree looks in the summer and in the winter. The story tells you why some trees lose all their leaves

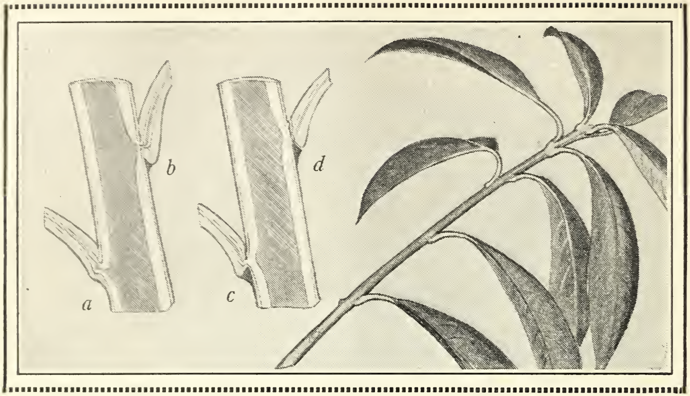
2. Why Leaves Fall

Some trees lose their leaves in the autumn. We call them deciduous trees. Some keep their leaves all through the year. These are the evergreens.

Have you ever seen anything more beautiful than the trees in the autumn? Everywhere one looks along the highways and in the woods, brilliant colors meet the eye. These colors are lovely for a short time; then the leaves are gone. Why must the leaves fall?

The leaves of many trees fall in the autumn for this reason. Trees cannot grow in winter. They do most of their growing in the spring and early summer. By the middle of summer the trees have done nearly all their growing for the year. Then the trees begin to get ready for winter. Doesn't it seem strange to begin to get ready for winter in the middle of summer? Many changes now occur in the trees. There is less sap flowing through the trunks. Many of the leaves are covered with dust or have been eaten by insects. They make very little food or none at all. Early autumn comes, and the trees are almost ready for winter.

When the leaves begin to change their color, their work is about ended. The food which they made is stored in different parts of the tree. They have nothing more to give; so they get ready to leave. A kind of thin skin, called a separation layer, grows between the stem of the leaf and the branch on which it is growing. Sometimes this separation layer is like a thin piece of cork. As soon as it is completed, the leaf falls. Did you ever try to break a green leaf from a tree? It wasn't such an easy thing to do. You had to pull hard. But after the separation layer has been made, the gentlest breeze will make the leaf fall. Even the weight of the dewdrops will often cause the leaf to fall.



This picture shows how the separation layer is formed. Which letter, *a*, *b*, *c*, or *d*, shows the leaf stem ready to leave the tree? What is happening at *a*, *b*, and *c*?

When you cut yourself, you have an open wound. You must be very careful of this wound. You must see that nothing harmful gets into it. You may put something on the wound to kill the bacteria, or germs, or you may cover it with a bandage. When the leaf falls from the branch, there is no open wound. Nothing harmful can get in. The separation layer covers and protects the place from which the leaf fell. There is nothing but a leaf scar left.

The brown leaves of the oaks and beeches often hang on the trees all winter. When spring comes they are still there. No wind seems strong enough to make them drop. Their separation layers are

Horse-chestnut twig showing leaf scars and winter buds. Can you find the leaf scars?

not perfectly formed, and so the leaves stay on the trees. They may stay until new leaves come.

Many people believe that the leaves fall because of frost. This is not true. An early frost often delays the fall of the leaves. It interferes with the making of the separation layer.

3. Buds

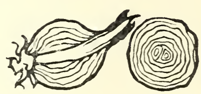
Besides getting ready for winter, trees get ready for spring too. If you look at twigs and branches after the leaves have fallen, you will find the little buds for the next year. These buds are on the branches before the leaves fall. A great many people think that buds are formed only in the spring, but this is not true. The tree is making

next year's buds while it is making its food in the summer. Some of the food that is made is stored in these buds. The little stems and leaves, and sometimes the flowers for the next year, are carefully folded inside the tiny buds.

Some buds, such as those of the horse-chestnut, have a hairy, or cottony, lining. There is a sticky cover on the outside. This lining and the sticky stuff protect them from strong, cold winds. They also prevent moisture from leaving the buds.

Evergreen trees are never without most of their leaves. They do not lose all of them in the fall. But there is a certain change for winter even in these trees. The green color of the leaves is not the same in winter as it is in summer.

Things to Do



1. Gather some autumn leaves.
2. See how many different colors you can find among the leaves.
3. Learn the names of the leaves that you find.
4. Plant a hyacinth or narcissus bulb in water and watch it grow.
5. Cut an onion lengthwise and crosswise. What do you find?
6. Place a carrot or a sweet potato in a wide-mouthed bottle of water. Watch and see what happens.

UNIT II

Migration

1. The Migration of Birds
2. How Birds find their Way
3. Other Animals that Migrate

MIGRATION

Long before Columbus discovered America, it was noticed that many birds disappeared in the autumn. At that time people knew little about the world. They had no idea where the birds went, and so they invented many strange stories to explain their absence.

Today we know more about where the birds go, but we find there is much about their migrations that we do not know. An aviator, such as Lindbergh, carries maps and instruments which help him in finding his way. What kind of maps and instruments do the birds carry when they make the long flight to their winter home and then back to their summer home? Even the young birds that have never made the trip before do not get lost.

Many birds travel over mountains, deserts, and across the seas; some travel from the Arctic to the Antarctic and back again every year. Why do they do it? Why do they not make their homes in the tropics and in that way escape all the dangers of so much traveling?

All these questions have puzzled people. Many scientists spend their lives studying them. In this unit we shall learn some of the things they have discovered.

Problem 1 · The Migration of Birds

1. Great Bird Travelers

You may have read about people who have traveled a great deal. Some of these people may have traveled around the world. We think of them as great travelers.

Here is a story of other great travelers. These travelers are not men or women, not boys or girls. They are birds.

One of the greatest travelers among birds is the Arctic tern. Some of the Arctic terns travel from the Antarctic regions to the far, far north each year. They make their nests and raise their young on the Arctic coast of North America. The mother terns often make their nests in the snow. In these snowy nests the little downy babies are born. It is said that an Arctic tern's nest has been found only four hundred and fifty miles from the north pole.

When the young have been raised the Arctic terns begin to fly back to the Antarctic regions. At the end of their journey, the birds have traveled over twenty-two thousand miles. They have flown almost as many miles as the distance around the earth. Don't you think these birds should be called great travelers?

A story is told of an Arctic tern that had a band placed on its leg in Labrador on July 23, 1928. This same tern was found near Natal, in South Africa, on November 14, 1928. It had traveled 9415 miles in four months. It had probably crossed the Atlantic Ocean to Europe and then traveled south to Africa.

The Arctic terns are building their nests in their northern home when that region is having its long, long day. During the Arctic summer the day is so long that the sun shines for weeks without setting. After the young have left the nest, the birds fly to their winter home in the far-off Antarctic continent. Once again they are in a land where the sun shines for weeks without setting. The Arctic terns are really out of the sunshine only a short time. This happens when they are on their way north, and when they are on their way south. Because of this they are often called "birds of sunshine."

Golden plovers are great travelers, too. They spend the winter in the southern part of Brazil and travel to the northern coast of North America in the summer. These birds do not come and go over the same route. When traveling north, they fly along the western side of South America to the United States. Here they follow the Mississippi Valley into Canada and the northern coast of

a. The Arctic tern with its young in their summer nest. *b.* A close-up of the legs and feet of the tern. Find the leg band. *c.* Golden plovers. In what way are they like the tern? *d.* Ruby-throated humming bird. Why have these tiny birds such long bills?

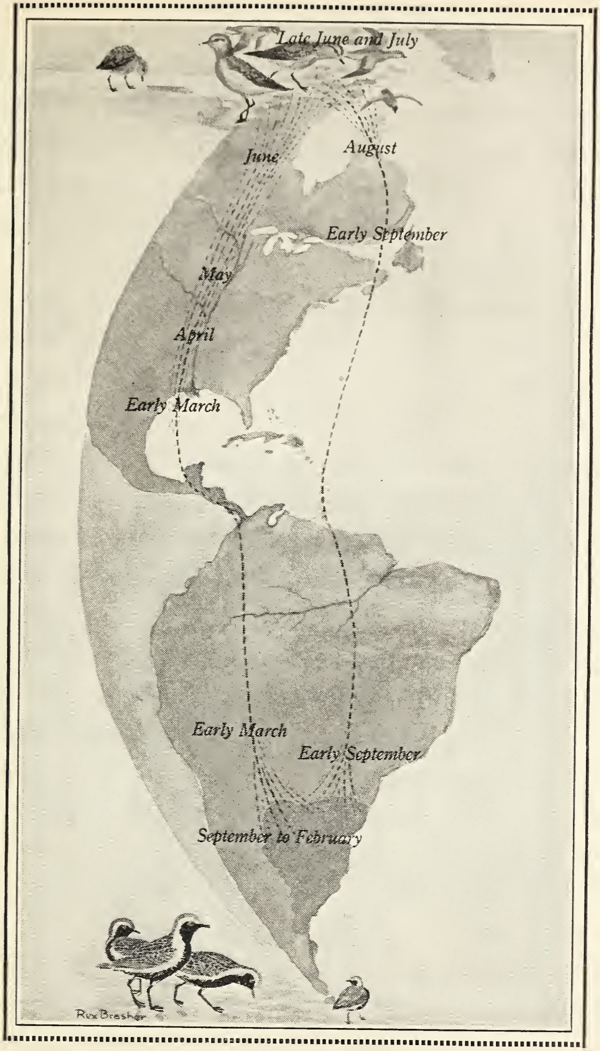
North America. In going to their winter home, they fly across Canada to Nova Scotia. Then they go south to Brazil. Sometimes they may fly a distance of twenty-four hundred miles without stopping.

Have you ever seen little humming birds in a flower garden? They hover about the blossoms to get the nectar; then they dart quickly away. These tiny birds have traveled all the way from Central or South America. One wonders how such little birds are able to take such long journeys.

We have learned a great deal about the long distances traveled by birds by putting bands on the legs of birds. These bands are usually made of aluminum. They are light in weight and do not harm the bird. They are marked and dated. One must get permission to put a band on a bird's leg. Permission to band birds in our country is given by the United States Biological Survey in Washington.

2. Why do Birds Migrate

Do you like to do puzzles? Some boys and girls are very good at doing them. The more difficult the puzzle, the better they like it. Sometimes questions are asked that are real puzzles because they are so hard to answer. "Why do birds migrate?" is one of the most puzzling questions that



See if you can trace the flight of the golden plover from its winter to its summer home and return[1]

[1] From Caldwell and Curtis's "Introduction to Science."

has ever been asked. No one seems able to answer it. Since early times scientists have been carefully studying the movements of the birds in order to answer the question. But these scientists are not yet sure what it is that causes the birds to travel over such long distances every spring and fall.

Some scientists think that birds migrate in order to get food. When winter comes there is very little food for birds in the cold northern countries; so most of them fly south, where it is warmer and where they find more food. Then the southern winter home becomes crowded with birds from the north. When spring comes, food is more plentiful in the northern countries, and the birds fly back.

This does not answer the question "Why do birds migrate?" We know that there are many birds that leave their northern homes in the late summer. They go to the south while the weather is still very warm and there is plenty of food for them in the north.

Other scientists think that the first birds of the kind that migrate today were born in the north. Their first homes were in the north. Then there came a great change in the climate of certain parts of the earth. It became so cold that the summer sun was not warm enough to melt the snow and ice formed during the winters. Snow

fell and hardened into ice. This went on for thousands of years. At last a huge mass of ice, a glacier, covered the northern part of North America. The icy winds from over the glacier blew across the country near it. The birds tried to get away from the cold of this great ice mass; so they traveled to the south, where the climate was warmer. Years and years passed, and the climate of the northern countries again changed and slowly became warmer. As the glacier melted, the birds moved north. As the seasons continued to change from spring and summer to autumn and winter, the birds soon formed the habit of moving regularly to the north and to the south.

Some people think that most birds return each spring to the places where they were born, in order to build their nests and raise their young. As soon as the young are raised and able to care for themselves, many of the birds again go to the south.

Here is another explanation which is given to show why birds migrate. At one time all birds lived in the warm south. The southern countries became very much crowded. It was difficult for all the birds to get all the food that they needed. This was especially true during the nesting time, when the young had to be fed. Young, growing birds need a lot of food. Many of the birds were

A picture of Joan and Ned seeing their first robin of the spring. You will often read about these children in this book, for they are usually doing interesting things

forced to find new homes in order to raise their families. They traveled into the northern countries.

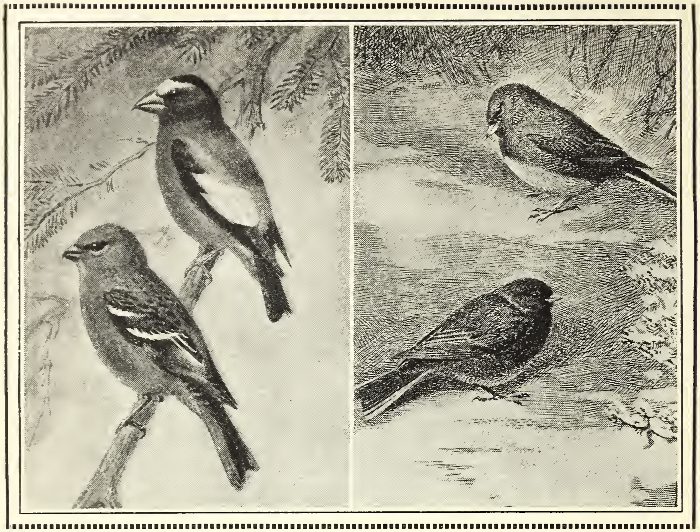
When the young birds were able to leave the nests and fly, the father and mother birds returned to their winter homes.

This explanation seems to be a good one. Many birds do build their nests and raise their young in places where they could not possibly spend the winter. They must migrate to other places. However, scientists are not willing to say that this is really why birds migrate. They are still giving a great deal of time and thought to the question.

The Baltimore oriole and its swinging nest. Which of the birds is the male? Why do you think the oriole builds a swinging nest?

3. The Time of Year when Birds Migrate

Some boys and girls always want to be the ones to see the first robin and the first bluebird in the spring. They watch for them day after day. They know that as soon as the snow has gone in the northern countries, many of the stronger birds will arrive from the south. Some of them come while the snow is still on the ground. These first birds to arrive have not spent the winter very far south. When the first mild days came, they began to travel north.

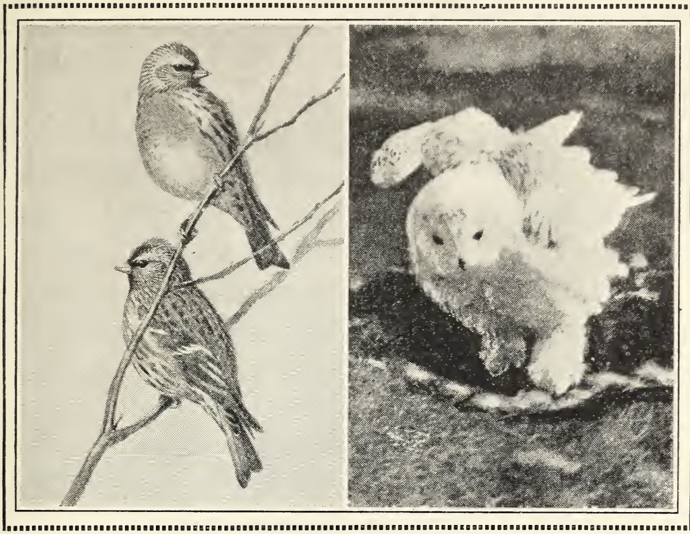


The pine grosbeak (left) has a bill fitted for getting the seeds out of the pine cone. How does it differ from the junco's bill? The junco (right) is a bird that visits us in the winter. Notice the low-cut vest and the white outer tail feathers of the junco. Look for it in the winter

When spring really comes and the weather grows warmer, most of the early travelers among the birds appear. Some of them will stay with us. They begin to make their nests. We call them our summer residents because they remain with us most of the summer.

The birds that come later in the spring may stop in some places to feed, but they soon pass on farther north. We call them transient visitants.

During April a few new birds arrive daily. By



The redpoll (left) is one of our winter visitors. What can it find to eat in the winter? At the right is the snowy owl. Would it be difficult or easy to see this owl in the winter? Why?

the last of May the great spring migration of birds is usually over. Most of the birds have then reached their nesting places. They do very little traveling during the nesting time.

The spring migration is a very orderly one. If the weather were always clear and pleasant and the birds could get enough food, their flight north would occur at exactly the same time each year.

The autumn migration of the birds is not quite so orderly. Many birds, such as the Baltimore orioles, some of the warblers, and the bobolinks,

leave their nesting places early. They return to their winter home long before cold weather comes and while there is still plenty of food. Many birds wait in the north until the nights become really frosty; then they hurry on their way south. Other birds wait until the cold winter storms drive them away.

In the late fall juncos, redpolls, tree sparrows, pine grosbeaks, and snowy owls are among the birds that come from the far, far north. They stay with us all winter. We call them winter residents.

Some birds remain in the places that have a mild, temperate climate most of the year. They are called permanent residents. Chickadees, nut-hatches, and some of the woodpeckers are birds that may be seen in the north, and in the south too, all winter. They search for food on the bare branches and trunks of the trees. The noisy voice of the blue jay may also often be heard during the cold weather. Even among the birds that stay through the winter, there is a certain amount of wandering back and forth.

In high, mountainous countries birds migrate by traveling a few miles up and down the slopes of the mountains. When the tops of the mountains are covered by ice and snow in the autumn, many birds suddenly appear among the foothills. They make no preparation for their

journey. They have only a short distance to go; so they do not need to hurry. There is plenty of food for them. When the snow and ice disappear from the tops of the mountains in the summer, the birds leave the foothills and travel up the slopes of the mountains. Then they build their nests and raise their young.

4. The Time of Day when Birds Migrate

Some birds travel during the day. Some travel during the night. Others travel either during the day or during the night. The time of day when birds migrate depends on the kind of bird.

Many of the small birds travel at night. Warblers, wrens, orioles, sparrows, and vireos travel when it is dark. These, and all small birds, have many enemies. By migrating at night they are able to escape some of their enemies.

Many of the small birds live in the woods. They are hidden from view by the leaves of the trees. This makes them shy and easily frightened. It seems better and safer for them to fly at night. When they travel all night, they become very hungry. They need food. They spend the day in feeding and resting. Sometimes these little birds travel great, great distances over land and water. If they flew by day, they would arrive at their

stopping places after sunset. They would be very tired. They might not be able to get the food they needed. People often hear the voices of these small birds as they fly on, calling to each other in the darkness.

The larger and stronger birds travel during the day. The robin, the bluebird, the blackbird, and the kingbird are among the birds that travel in the daylight. Many of these birds stop to feed while they are on their way.

When these birds are traveling north and south, they often have to cross great bodies of water and some places on land where there is very little food. When this happens, they change their time of migrating and fly at night. In this way they reach places where they can feed by daylight.

There are birds that feed as they fly. Swallows and chimney swifts do this. They need not stop for food.

Ducks, geese, cranes, loons, and hawks are very large birds, and they usually travel during the day. They rest at night. If there is a sudden change to cold weather when they are migrating, they may travel either by day or by night. Long lines of them may often be seen hurrying to get away from the cold.

After the birds begin their flight to the north or to the south, they almost never turn back.

They may stop on the way if the weather is stormy and unpleasant.

While the birds are traveling back and forth, they meet many dangers. Sudden cold and snowstorms occur. The birds are not able to get away from the storm. They are tossed about by the wind and blinded by the snow. Hundreds of them die during the storm. The larger migrating birds often attack and kill the smaller, weaker ones. Other animals that are prowling about frequently catch and kill the birds when they stop to rest and feed.

How fast do birds travel when they are migrating? The birds that leave their winter homes when the first warm days come travel slowly. Stormy weather often prevents the early birds from making much speed. The birds that wait until April and May to start north move very rapidly. Then the weather is warmer, and most of the bad storms are over. It is thought that the average speed of the small birds is about twenty-three miles a day.

The blackpoll warbler starts north from South America at the rate of thirty to thirty-five miles a day. As it travels through the United States to northwestern Alaska its speed is much faster. Some days it flies two hundred miles. It travels this distance in order to raise its young.

In some places the robin travels only eight miles a day. In other places it may travel seventeen miles a day. In still other places it is known to fly over seventy miles in one day.

It has been found that some birds can travel over two hundred miles an hour. To travel so fast, an airplane or automobile must be built for speed and have a good motor. Birds too are built for speed by having light bodies, strong wings, plenty of energy, and by being able to steer themselves. Aviators have found certain birds able to circle around their airplanes which are flying seventy miles an hour.

Birds may be helped or hindered in their flights by the wind. Did you ever try to walk when a strong wind was blowing in your face? Were you able to walk very rapidly? When a bird flies against a head wind (that is, when a strong wind is blowing in its face), it has difficulty, too. It must use a great deal of its strength and energy. Because of the head wind, the bird's speed is cut down. It cannot travel fast. The bird also has trouble when it travels with the wind. Then its feathers are constantly being ruffled. This interferes with the bird's flight. It is difficult for it to keep its balance. Light winds from other directions help to push the birds on their way.

Many of the small birds find it difficult to fly

The eagle. Where does this bird make its nest? How does it carry its prey? Is it a strong or weak bird? Why?

even when they are near the earth. They must keep their wings in constant motion to hold themselves up in the air. Watch some of them and see if this isn't true.

Do you know how high some of the birds fly? Large, strong birds have a wide wing spread. It is easier for them to fly high than it is for the smaller birds. Hawks, eagles, cranes, among our northern birds, and the condor of the Andes belong to the group of strong birds. They may fly very, very high.

Aviators have found out a great deal about the

height at which birds fly. They tell us that only now and then have they seen a bird higher than a mile and a half above the earth. They have found most of the birds that migrate flying less than three thousand feet above the earth. Sometimes they have seen a bird flying above the highest mountains. This doesn't often happen. Birds have nothing to gain by flying at a great height, and most birds fly below the clouds.

Things to Think About

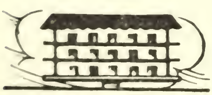
1. What birds remain near your home during the summer?

2. What birds remain during the winter?

3. How do these birds help man?

4. What are some of the dangers that birds meet while they are migrating?

5. In what ways is an airplane like a bird?



Things to Do

1. On a map of the world —
   a. Trace the journey taken by the Arctic tern in going from its winter to its summer home.
   b. Use the scale of miles and see if you can find out the number of miles the tern travels.

c. Trace the route of the Arctic tern that traveled from Labrador to South Africa.

d. Trace the two routes taken by the golden plover.

e. Find Brazil, the winter home of many birds.

2. Watch for the return of the birds near your home in the spring. Keep a record of the birds you see.

a. Write the name of the bird.

b. When did you see it?

c. Where did you see it?

d. Were there many birds of the same kind?

e. Which birds began to build their nests?

f. Write other interesting things that you noticed about the bird.

3. See if you can get some birds to remain near your home. Make and put out some bird houses for them. Bird baths and feeding platforms may cause some birds to remain near your home.

Problem 2 · How Birds find their Way

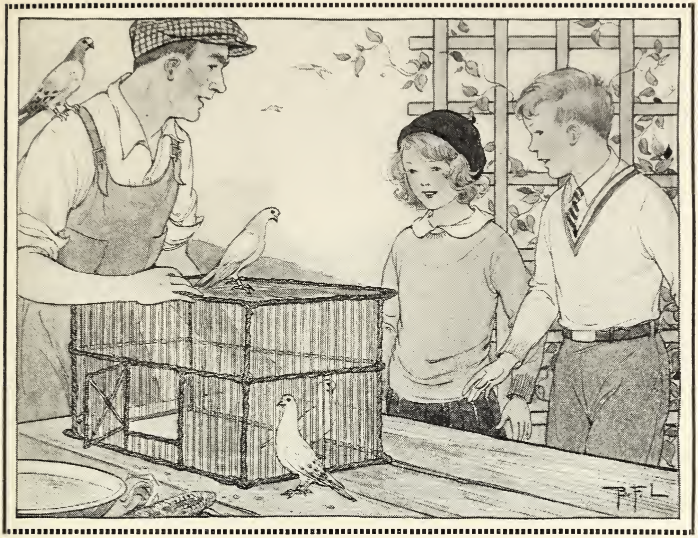
1. The Flight of Birds

Most birds seem to have very good sight. They are able to see a long distance away. The birds that fly in the daylight may be guided a great deal by their sight. The night-flying birds may also depend on their sight to guide them on their way. On a clear moonlight night these birds fly very high. When the night is cloudy or foggy, they fly only a short distance above the earth.

The dog and the cat find their way about by what is called their sense of direction. We think that birds may have a sense of direction, too. However, we are not sure of this.

We know that homing pigeons have traveled great distances and returned again to their lofts. They have done this with very little loss of time. Their sense of direction may have helped them to find their way.

Sometimes homing pigeons are given special training in flying. The first day they fly over a few miles and return to their starting point. Each day the number of flying miles is increased until the pigeons fly hundreds of miles at a time. They fly mostly in the same direction. Many of the pigeons take only a short time for these flights.



Joan and Ned are interested in watching the training of these homing pigeons. The story tells you how the pigeons are trained in flying

Certain things have been tried with homing pigeons in order to see what they would do. Some pigeons were carried a long distance from their home. They were carried in cages. As soon as the birds were set free, they started to fly back to their home. Other pigeons were carried the same distance from their home in covered cages. The covers were removed, and the birds were given their freedom. For a long time the pigeons seemed confused. They didn't know where to go. They flew round and round. They lost much time in this way before starting on the return flight.

A lighthouse on a rocky coast. Tired birds may rest on the platform under the light

From the many experiments that have been tried with pigeons, it would seem that they do recognize places and that their sense of direction guides them. It may be that all birds are helped in traveling back and forth by their sense of direction.

On dark, stormy or foggy nights many birds get lost. They cannot find their way because of the bad weather. Many of them fly to the rays of light that are thrown out by lighthouses. They often fly about for hours in the mist around the light. Then they become tired out and fall.

In many places people who are interested in protecting the birds are having platforms built under the lights in the lighthouses. On these platforms the birds may rest until they are ready to fly on their way.

2. How the Early People explained the Migration of Birds

Early people had many strange ideas about birds. They too tried to explain why birds migrated. Many, many years ago they noticed that the birds disappeared from certain places in the autumn and winter. When spring and summer came, the birds returned. This fact seemed very strange to these people of long ago. They wanted to know where the birds went. Why did they go? Because they thought so much about these questions, they imagined and told all kinds of fanciful stories about the disappearance of the birds.

Some of the people thought that the birds went straight to the moon when they left in the autumn. It took them about sixty days to reach the moon. They didn't need to eat while on their way. They would not starve because they had plenty of fat stored up in their bodies. There were no objects between them and the moon; so they closed their eyes and flew on, fast asleep.

There were other people who said the birds went into caves and hollow trees and slept during the long, cold winter. They thought that some birds buried themselves in the mud at the bottom of streams and in swampy places. They were sure that swallows and chimney swifts passed the winter in this way. To prove this, they told a story about some men who were fishing. When the fishermen drew in their nets, they found as many sleeping swallows as fish. They also said that swallows were dug from a depth of two feet in the mud. In a half-hour after they were dug up, the swallows awakened and became lively and active.

There were still other people who believed that the birds changed from one form to another as winter came. The robin was supposed to take the form and colors of the redstart. Certain birds that lived in marshy places were thought to change into frogs.

All these stories were told by the early people because they were so anxious to explain why the birds disappeared in the autumn and winter. We know that these stories are not true. Birds have been migrating for thousands of years. The scientists of today cannot tell us why they do it. So we see what a difficult question the early people tried to answer.

Things to Think About

1. What stories have you heard or read about some particular homing pigeons that were sent with messages?

2. How do captains on board ship find their way?

3. How do aviators find their way?

4. If you are in a place that is new and strange to you, how shall you find north, south, east, and west?

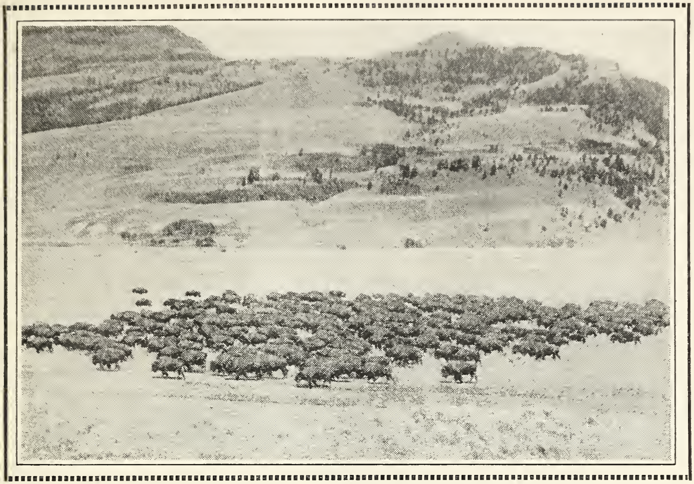
5. Why cannot birds fly to the moon?

Problem 3 · Other Animals that Migrate

We know that many animals travel about from place to place. They may travel in search of food. They may travel to raise their young. They may travel to find a different climate. Whatever the cause may be, many animals do travel from one place to another.

In early times man had to hunt and fish in order to live. There were no markets. There were no stores where he could buy what he needed. He soon learned to know the habits and the movements of the animals that would furnish his food and clothing. He found that certain animals were in certain places at certain times of the year. They were in other places at other times of the year. The great herds of buffaloes, or bisons, traveling across the plains filled him with joy. They meant food and clothing for him. These buffaloes were migrating. They were hunting for new pastures. In the Middle West many of our present highways are along what were the trails of the early migrating buffaloes.

The Indians have many old legends which tell of the coming of the caribou, or reindeer, to their hunting grounds. These animals migrate by thousands each year. They must migrate to find new pastures.



Migrating buffaloes. Why didn't this herd of buffaloes stop here to feed?

Reindeer feeding on moss. Sometimes these animals have a very difficult time to find food in winter

© Field Museum of Natural History

Polar bears on the ice. Can you select the mother bear? How many cubs do you see? Why are these bears able to live in such a cold place?

Reindeer feed on moss. During the winter they travel from the shore far into the country to find it. In the summer, when flies and mosquitoes make their appearance in the country away from the shore, the reindeer migrate back to the coast.

Polar bears spend much of their time during the summer on the loose ice far from shore, hunting their food. In the winter this ice moves southward. The polar bears travel south with the ice. They are then often found on land. The mother bear usually selects a den on the ice. Here in the silence of the long, cold, northern night, one or two little naked cubs are born. The mother takes

These salmon are migrating upstream. Their journey isn't an easy one, for many times they must leap over falls in the river

good care of her young. When the ice breaks up and the cubs are able to follow, the family migrates a greater distance to the north.

Beavers are often found wandering about searching for new forests and fresh food.

On the slopes of the mountains the sure-footed sheep and the mountain goats are found. They travel up and down the slopes, hunting for food, shelter, and warmth.

Salmon travel great distances. They go from the salt water of the ocean to the headwaters, or the source, of certain streams. They take this long journey to spawn, or lay their eggs. They lay

their eggs in the gravel and sand on the river bed. The eggs develop slowly. About eight weeks after they are born, the little salmon move through the water searching for food. When the little fish measure six or seven inches, they are ready to go out to the ocean. Here they grow very rapidly. A few years are spent in the ocean in feeding and growing. Then the salmon are ready to spawn. They leave the ocean and go back to the place where they were born.

The journey from the ocean to the source of the stream is a difficult one for the salmon. The fish must travel against the strong current in the rivers. They must leap over many falls. They probably travel without food, living on the fat that is stored in their bodies. Few of the salmon ever spawn more than once. Their lifework then seems to be ended, and they die.

Shad leave their home in the sea and migrate long, long distances up rivers. They also go to the headwaters of the streams to lay their eggs.

Have you ever seen an eel? It is really a salt-water fish, but it spends most of its life in fresh or slightly salty water. Eels migrate, but they do not do it in the same way that shad and salmon do. On autumn nights the full-grown eels may be found traveling from the quiet waters of the rivers and ponds to the sea. They swim out

into deep water, lay their eggs, and probably die. The full-grown eels never return to their homes in the rivers and ponds. Very little is known about the eel's eggs. When young eels are a certain size, they migrate toward the shore. They pass up the fresh-water streams in a procession to feed there and grow.

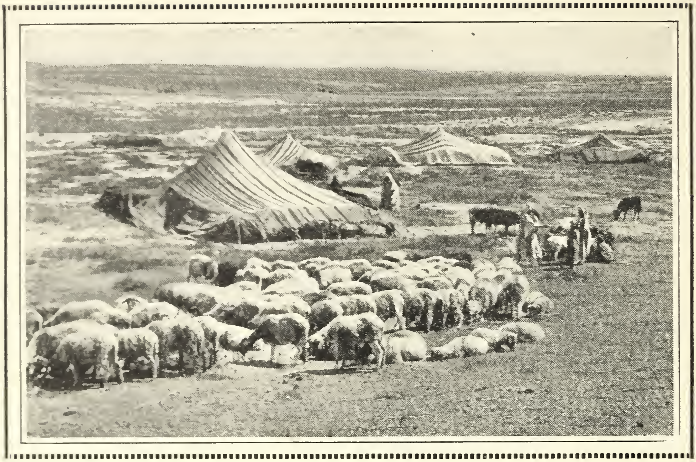
The Alaskan fur seal, the whale, and the polar bear are other migrating animals that spend much of their time in the sea.

The seal travels far south through the warmer water of the ocean each year. When spring comes, it is sure to return to the islands in Bering Sea to raise its young.

Whales are large sea mammals. They travel about, trying to find a more even temperature. The need of food may be partly responsible for their movements. The killer whale will follow, kill, and feed upon seals. It travels about to find them.

Very little is known about the migration of insects. The monarch butterfly, the cabbage butterfly, and the locust are insects that are supposed to migrate.

It is thought that the monarch butterflies seen in the north in the spring have come from the south. Most of them return to the south during the winter.



Arabs migrating with their flocks. In what kind of country have the Arabs pitched their tents? Why must they migrate?

Now and then migrating locusts appear in great numbers in certain countries. They do much damage to plant life in these countries. Sometimes whole fields of grain are destroyed by the locusts.

Man too migrates. From Asia he migrated westward into Europe. He crossed the Atlantic Ocean and spread into the hunting grounds of the American Indian. Today people who live on the borders of desert countries must travel about to find food for their flocks.

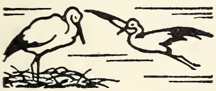
There are many animals that migrate that are not mentioned in this story. Only the animals that most of us know about or have seen are given.

You may be able to name other animals that travel regularly from place to place. You may like to make a list of the names of these animals in order to see how many you know.

Things to Think About

1. Why do we no longer find great herds of buffaloes wandering over our plains?

2. What is the best time of the year to catch shad and salmon for food? Why?



Things to Do

1. Make a list of the animals not given in this unit that you know do migrate.

2. Name some of the countries of the world that have suffered much damage because of migrating locusts.

UNIT III

Hibernation

1. Warm-blooded and Cold-blooded Animals
2. Some Animals Hibernate

HIBERNATION

Not all animals can escape the winter by going to a warm country. They cannot move fast enough to get away, or perhaps they have never got into the habit of migrating. So they must stay, even though the cold winds blow, and snow and ice cover everything.

Some animals must hunt for food every day during the winter. Perhaps they dig the snow away with their hoofs in order to get nibbles of grass here and there, or perhaps they find seeds, nuts, and other things to eat. They need a great deal of food because they are exercising in the cold. Some animals avoid this by storing their food away in some little corner all their own before winter comes.

Some animals neither migrate nor look for food in winter. They go off into some protected place away from the cold air and go to sleep. How can they live all winter long without eating or drinking? A man who spent much of his time studying animals once said that the woodchuck goes farther than the bobolink in the winter. The bobolink goes south, but the woodchuck goes to the very doors of death. What do you think he meant? You can find out by reading this next unit.

Problem 1 · Warm-blooded and Cold-blooded Animals

We are always finding out new and surprising things about living animals. One of the things we have learned is that some of them are warm-blooded, and some are cold-blooded. Man is a warm-blooded animal. All mammals are warm-blooded. Warm-blooded animals are animals that always have the same temperature.

When we are well our temperature is usually 98.6° F. It doesn't make any difference where we are, indoors or outdoors,— in the summer or in the winter,— if we are well, our temperature stays the same. There may be times when our temperature is not 98.6° F. If it is higher than 98.6° F., we have fever. If it drops below 98.6° F., we may have a chill.

Most warm-blooded animals can remain lively and active during the entire year. The cold winter weather does not seem to trouble them. Most of them have coverings of hair, feathers, or fur. Some of them have thick layers of fat under their skin. These coverings and layers of fat help to keep the animals warm. They prevent the heat from leaving their bodies. Name an animal that has a layer of fat under its skin.

Snowshoe rabbit in its winter setting. What do you think this rabbit will find to eat?

The rabbit which you see in the picture must hunt for its food all winter. When the snow is on the ground, it cannot get tender grasses and clover. It may have to travel far away from its cosy nest in the snow. It needs its thick, warm covering of fur.

The whale hasn't a covering of fur or feathers, but it has a layer of fat inside its skin. Because of this, it may spend much of its life in icy waters and not suffer from the cold.

Birds are not mammals, but they are warm-blooded, too. Their temperature is much higher than our temperature. A bird's temperature may

be 104° F. It may even be as high as 112° F. It is natural for birds to have this high temperature.

Cold-blooded animals are not like warm-blooded ones. Toads, frogs, snakes, and turtles are cold-blooded. They have no regular temperature. Their temperature may be high or it may be low. They have about the same temperature as the rocks, the soil, the grasses, the air, or the water where they happen to be. Places where the temperature is about the same most of the time make splendid homes for them. They have no outside covering of hair, fur, or feathers to keep them warm. They cannot be active outdoors during cold weather. When winter comes certain changes occur in their bodies, and they go to sleep.

All animals, whether they are warm-blooded or cold-blooded, must eat at times during their lives. Most mammals usually eat every day. You feed your pet animals every day. You may feed your dog twice and your cat three times a day. You also see that they have water to drink.

Cold-blooded animals usually can go a much longer time without food than warm-blooded animals. Some snakes can go for months without eating.

There are several reasons why animals must have food. One reason is that little animals grow to be big animals. The food that little animals

eat is used by their bodies in making them grow to be big animals. If the young animals didn't eat, they would never grow up.

Another reason why animals must have food is that their bodies are always changing. New materials are needed to supply the worn-out parts. When the parts of a machine in a factory wear out, new parts are bought for the machine. Sometimes people have to buy new parts for their automobiles. An animal doesn't buy a new part for its body. It eats food. Then the body uses the food in repairing itself. An automobile cannot repair itself.

Animals must also eat food in order to make heat for their bodies. This is especially true of a warm-blooded animal. Unless it eats food, it cannot keep its temperature at 98.6° F. Birds need much more food for their size than mammals because their temperature is higher. They seem to be hunting for food all the time.

Sometimes animals exercise to keep their bodies warm. Perhaps you have made yourself feel warmer by running when you felt chilly. Some animals shiver when they are chilly. Man shivers when he is chilly.

Although bees, like all other insects, are cold-blooded, they can keep their hives cooler on a hot day than it is outdoors, and they may actually make the inside of their hives warmer, on a cold

day, than the air outside. They cool the hive by fanning their wings, just as we use an electric fan. They can warm the hive a little bit by exercising.

Ants build their homes in order to get the greatest amount of heat from the sun. They even carry their eggs and young about in the nest so that the sun may warm them.

Birds and mammals are warm-blooded animals; all other animals are cold-blooded animals.

Things to Think About

1. What is the difference between warm-blooded and cold-blooded animals?

2. Why is it necessary that your temperature should be about 98.6° F.?

3. Why is the whale, which is a warm-blooded animal, able to live in cold, icy waters?

4. Why do birds need a great amount of food?

Things to Do

On a separate piece of paper fill the blank places in these sentences.

1. Animals must have food so that their bodies may ______ themselves.

2. Animals must have food so that ____ may be made for their bodies.

Problem 2 · Some Animals Hibernate

1. What is Hibernation?

Did you ever see toads and frogs hopping about outdoors in the winter? Long before really cold weather comes, they have disappeared. They have found places deep down in the ground or in the mud at the bottom of a pond. Here they have buried themselves in order to escape the cold of winter and have gone to sleep. We say that they are hibernating.

You will not see turtles and snakes crawling around hunting for food in winter. The turtles have buried themselves in the sand and mud of the streams. Many of the snakes have found safe places under the rocks and bowlders or on the stony hillsides. They have crawled into these places to rest and sleep until winter has passed. These animals are also hibernating.

Passing the winter, as some animals do, in resting and sleeping all or most of the time is called hibernation. We usually think of hibernation along with cold weather.

There are animals that live in warm countries that become sleepy and move about very little during a long, dry season; but we do not think of these animals as hibernating.

Scientists are not willing to say that the animals that hibernate do so because of the cold. Many of them think it is because the hibernating animals can't get the food they want in cold weather.

Both warm-blooded and cold-blooded animals hibernate, but the number of warm-blooded animals that do so is very small. Most warm-blooded animals run around all winter.

Many animals that hibernate during the winter prepare for their long sleep in a special way. Some of these animals are busy all summer getting ready for the winter. They gather and store great piles of food. This food is stored in the burrows which they make for themselves in the ground. The food and the animals will not freeze, for the burrows are made deep so that the frost will not reach them. When the cold weather comes, the animals go into their burrows, curl up, and hibernate. At certain times during the winter, some of them may awake and eat; but they go to sleep again. The chipmunk does this.

Other animals eat a great deal of food during the summer. That is their way of getting ready to hibernate. As cold weather comes, they eat more and more food. Instead of storing food in their burrows, they store it, as fat, in their bodies. These animals usually hibernate all winter without

waking up. They live on the fat stored in their bodies. The woodchuck hibernates all winter.

When their hibernating time comes, many changes occur in the bodies of the animals. Their mouths, noses, and eyes close tightly. Their hearts beat very slowly and feebly. Their breathing becomes fainter and fainter, until they don't seem to breathe at all. The fat in their bodies is slowly used, and many of the animals grow thinner and thinner and lose weight. They are still alive, but they are very, very sleepy and they remain very quiet.

Do all animals that hibernate sleep the same length of time?

No. The length of time that hibernating animals sleep differs for different animals. Some animals may sleep four months. Some may sleep less than a month. A scientist once kept some hibernating land snails for three years. They were wrapped in paper. At the end of three years, the paper was taken off. The snails were still alive.

Some animals hibernate only during a part of the winter. They are called partial hibernators. Chipmunks, bears, raccoons, bats, and skunks are partial hibernators. The skunk may sleep only a few weeks during the early part of the winter. If mild, warm days come while it is sleeping, it may awake and come out of its den.

The skunk is a most interesting little animal. He is quite a friend to man, for he eats many troublesome and harmful insects

Some animals hibernate only when the weather is very stormy and cold. When it grows warmer, they awake and become active. This is true of porcupines, opossums, muskrats, pocket gophers, moles, meadow mice, and squirrels.

Other animals rest during the entire winter. They are the regular hibernators. Woodchucks, ground squirrels, turtles, snakes, lizards, snails, toads, and frogs belong to this group. The mourning-cloak butterfly, the queen bumblebee, and the potato beetle are also regular hibernators.

You have been reading about animals that hibernate during the winter. There are many animals that do not sleep in this way. They do not prepare for cold weather. Deer, rabbits, foxes, and many other animals must hunt about for food all winter long.

The next stories will tell you more about some of the hibernating animals.

2. The Woodchuck

The woodchuck has other names. He is called ground hog as often as he is called woodchuck. Many people prefer to call him ground hog.

The woodchuck usually lives in an open field that is not far away from a wood or a hill. His home is in a long burrow which he makes under the ground. He makes this burrow very carefully so that his nest of grasses and leaves will keep dry. There is a front door and a back door to his burrow; so the woodchuck may go into his burrow one way and come out another. Near the

A woodchuck sunning himself on a log

front door he leaves a little pile of loose earth, but the back door is usually hidden under sticks, twigs, and stones. He often closes the doors of his nest in order to keep other animals out.

In the early morning or the late afternoon, the woodchuck travels from his burrow to the meadow or the nearest grainfield to feed. He likes all kinds of juicy grasses, vegetables, and fruits. If there is a vegetable garden near his home, he visits it too. He eats food all summer. In the fall he eats more and more food. He eats enough food to last him through the winter.

When the woodchuck has finished eating, he

goes into his warm, cozy nest, curls up, and hibernates. His temperature gets lower and lower. One can scarcely see him breathe. His heart beats just enough to keep the blood flowing very slowly through his body.

If a woodchuck is dug out of his burrow in the middle of winter, he does not seem to be alive. His body is stiff and cold. But he is not frozen. If he is kept in the warm sunshine long enough, he will awake.

The woodchuck is a rodent, that is, a gnawing mammal. He is related to the squirrel, the beaver, and other animals that have sharp teeth for gnawing. His hair is mixed gray and brown. His short, flat tail and the underside of his body have scarcely any hair. He sits up like a squirrel and holds his food between his forepaws. He climbs upon a log or old tree stump to see what is going on about him. Sometimes he gives a shrill, harsh whistle.

Woodchucks are born in April or May. There may be three or there may be as many as nine. It is great fun to watch them follow their mother through the fields and meadows. The mother takes care of her young for a few weeks. Then they take care of themselves.

A woodchuck often climbs a tree to get away from a dog; but if he is cornered, he shows great courage and is a good fighter. His sharp teeth and

strong feet and claws help him to protect himself. He often whips a dog much larger than himself.

3. The Bat

The bat is the only mammal that really flies. The flying squirrel glides downward through the air, but it does not really fly.

In the evening the bat flies in and out among the branches of the trees, catching insects, while most of the birds are sleeping. Before the light of morning comes, he is again hunting for food. He doesn't have to stop to feed. He eats as he flies. Mosquitoes, moths, and other insects are his food.

Nearly all mammals have four legs, but the bat has wings instead of legs. They are most interesting wings, too. There are many long bones in them, and the bones can spread out far apart or can fold up together. These bones make a sort of framework, over which a thin, strong, silky skin is tightly stretched to form the wings. The body of the bat has a covering of soft hair, or fur, but the wings have no covering at all. There are many little blood vessels and nerves in them. Even if the bat could get its insect food in the winter, its wings would not be able to stand the cold. The bat could not fly in the cold weather; so it goes to sleep.

Bats. How many bats do you see in the picture? Can you tell from this picture what bats like to eat? Are all these bats doing the same thing?

The bat does not make a nest or burrow for his long sleep, as the woodchuck does. He finds an old deserted building, a barn, a cave, or a hollow tree. Then he hangs himself up, head down, and hibernates.

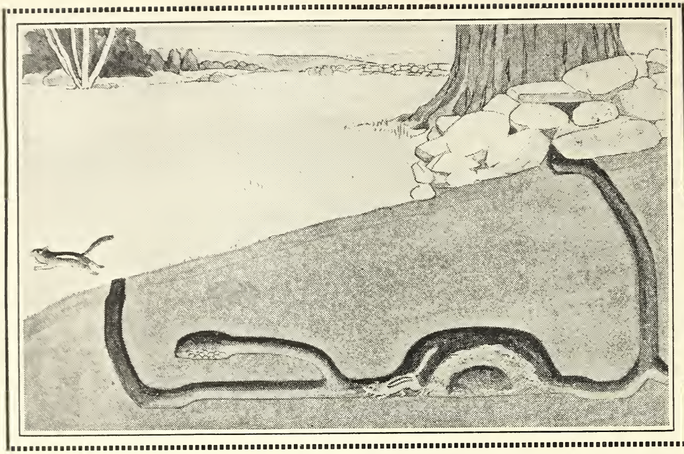
Neither does the mother bat build a nest for her young. When she flies about hunting for food, the little bats hang on her breast, and she takes them with her. She does not need to catch insects for her young, for they are nursed at their mother's breast. After they become too fat and

heavy for the mother to carry with her, she leaves them in some protected place and goes off alone. When she has found enough food, she returns again to her little ones.

The bat is a very helpful little animal. It eats mosquitoes, flies, and other insects that bother us. Some people are afraid of bats because they have heard such foolish stories about them. These stories are not true. There is no reason why one should be afraid of a bat.

4. The Chipmunk

The chipmunk is a friendly, playful little fellow. He looks like a very small squirrel, except for the black and white stripes along his back and sides. These stripes often protect him. They look so much like the grasses and underbrush that they make him difficult to find when he is at rest. You see him only when he moves. He spends more time on the ground than in the trees. His claws are not sharp enough for much tree-climbing. He is often found in cemeteries, where he hides and burrows under the tombstones. Because he spends so much of his time on and in the ground, he doesn't need a bushy tail. It would soon become very dirty and untidy. On a stormy day he goes under a log, a tree stump, or a stone and rests.



The chipmunk and his burrow. In which nest has he stored food?

The chipmunk gathers plenty of food for his winter's sleep. Sometimes he hides great quantities of nuts, seeds, and grains under logs, in holes in the ground, and in trees until he has time to remove them to his burrow. It is said that chipmunks and squirrels can tell the difference between good and bad nuts without opening them. They will take the good nuts and leave the bad ones. How do you think they know good nuts from bad ones? Besides nuts, they often eat apples, wild berries, some kinds of vegetables, and mushrooms.

Few animals build a better home than the chipmunk. He usually makes his burrow on a

dry hillside. The entrance to it is only large enough for his own body. A long tunnel runs back from the entrance to the warmly lined nest. He also prepares for escape in time of trouble by making a back door.

It is fun to watch the chipmunk when he is making his burrow. He looks very much like a child who has the mumps. He has little pouches, or pockets, on the inside of his cheeks. In these pouches he carries every bit of loose earth away from the entrance of the tunnel he is digging, so that there is no pile of earth, no sign, to show one where his nest is.

I once saw a chipmunk sitting on the branch of a tree, watching some young phœbes in their nest. Slowly he moved nearer and nearer to the nest. The mother bird became wild with fear for the safety of her babies. She flew up and down and round and round, scolding all the while. Other phœbes heard her call of distress and flew to help her. Soon the branches of the trees seemed to be full of greatly excited birds. The chipmunk finally gave up the chase and left the tree. The birds had won. But all the afternoon the mother bird remained near her nest, watching. The chipmunk did not return.

The chipmunk spends most of the winter hibernating in his nest. On mild days he may awake

and come out of his burrow. He usually eats some of his stored-up food at this time. Then he goes back. Now and then he awakes, eats some food, and goes to sleep again without going outside.

At all times the little chipmunk's life is in danger. Snakes, cats, and other larger animals are his enemies. Because of this the chipmunk is always alert. When he is running, he often stops, sits up, and looks about. Sometimes he gives a shrill whistle which resembles the call of a bird.

5. The Mourning Cloak

On a warm sunny day in late February or early March, a large, dark-brown butterfly may be seen flying about. It is the mourning cloak. Its dark-brown wings have a narrow border of bright yellow. Near the yellow border there are many lovely, bright-blue spots that add to the beauty of the butterfly.

If you watch the mourning cloak as it flies about, you may see it stop on the trunk of a tree, fold its wings above its body, and uncoil its long black tongue. Then it begins to drink the sweet sap that is slowly coming out of a small hole in the tree. Other mourning cloaks may soon join it. They too are hunting for food.

The mourning cloak hibernates during the

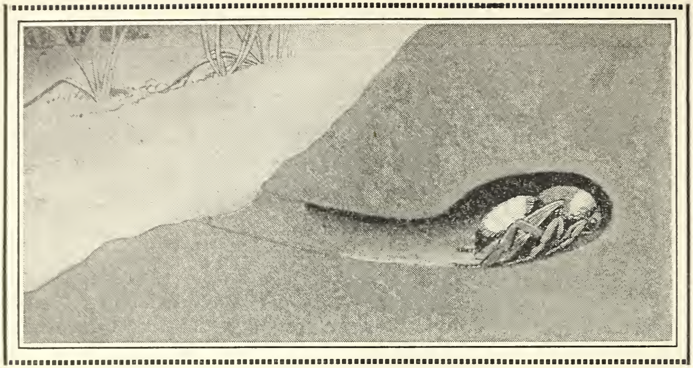
The mourning cloak. This butterfly hibernates in the winter. The story tells you about it

winter. As very cold weather comes, this butterfly finds a safe place where it will be protected from storms. This place may be in a barn, in a hollow tree, under a woodpile, or in any other sheltered spot. Then it folds its wings above its body and goes to sleep.

6. The Queen Bumblebee

The queen bumblebee passes the cold wintry days hibernating. She usually finds a dry, sandy place and digs herself a little nest. Here she rests while cold weather lasts.

When the queen bumblebee awakes in the spring, she crawls out of her winter home and hunts



The queen bumblebee. The bumblebee has found a nest in which to spend the winter. This bee is very fond of the red clover flowers

for a larger nest where she can lay her eggs and raise her family. She usually selects an old burrow that was once the home of a field mouse. Then she gathers enough pollen and nectar from the flowers to make a loaf of beebread. On this beebread she lays her eggs. The eggs soon hatch out, and the new bumblebee family has begun.

7. Snakes

Snakes are cold-blooded. They belong to a class of animals called reptiles. Sometimes they are called serpents too.

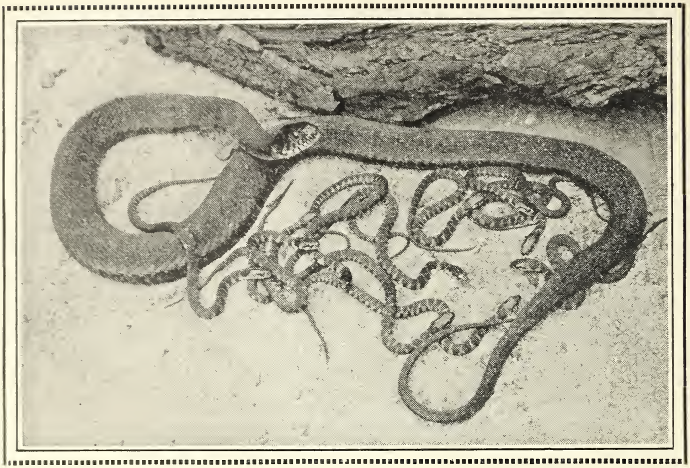
Some snakes are hatched out of eggs that the mothers lay, but others are born alive. One mother snake may have from ten to thirty, or even more, young. She watches over and protects them for a

short time; then the young snakes take care of themselves.

Snakes cannot live outdoors during our cold northern winters; so they hibernate until spring. The favorite hibernating places of many snakes are under big bowlders and rocky ledges or on stony hillsides. They crawl into safe places under the bowlders and rocks and go to sleep. When the days grow warm in the spring, the snakes awake. They crawl out of their winter homes, but they still seem sleepy and inactive. They lie quietly for hours in the warm sunshine. During the long summer days they wander off from their homes, hunting for food.

Nearly all snakes feed on living animals. Some of them find their food on the land. Others climb shrubs and trees to find their food.

Many snakes swallow animals alive. Sometimes they swallow animals that are larger than themselves. Snakes can do this because their bodies are very elastic. There is also an extra bone, which acts like a hinge, between the upper and lower jaws in the mouth of a snake. This hinge bone allows a snake to open its mouth very, very wide when it is getting its food. Some snakes chase the small animals they feed upon and catch them in their mouths, but other snakes coil themselves around the animals and squeeze them to



A water snake and her brood of little ones. How many young snakes can you count? These snakes were born alive

death. Most snakes are able to get along without food for weeks and sometimes even for months.

As snakes grow older they split their skins and shed them. This may happen two or three times a year.

Most people think that all snakes are poisonous and harmful. This is not true. While there are a great many different kinds of snakes, only a very few of them are really poisonous. The best-known harmful ones in our country are the rattlesnakes, the copperheads, and the cottonmouths, or water moccasins. In some of our Southern states the poisonous coral snakes are found. The other

A rattlesnake raised ready to strike. Notice the markings on the back of the snake

members of the big group of snakes are harmless. Many of them are very useful to us. If we take the time to become acquainted with some of the harmless snakes, we shall find them interesting and friendly.

The garter snake is found in many parts of our country. If the young snake is caught and tamed, it makes a fine little pet. In its wild state it eats earthworms, insects of all kinds, toads, frogs, and salamanders. The snakes are about six inches long when they are born.

It would be wise to learn to recognize a copperhead and a rattlesnake. If you live in a big

city, you may visit the reptile house in the zoological park. Here you will see the snakes. If you can't visit a reptile house, try to find good pictures of the snakes. Poisonous snakes usually have heads shaped like a triangle. They have blunt tails. The rattles on the tail of the rattlesnake always help one to know it.

When you are hiking or picnicking in a rocky country or a country containing many big boulders, where is the best place for you to sit to eat your lunch? Why?

8. Turtles

Turtles belong to the reptile class of animals. They are cold-blooded and harmless.

People have found turtles that were over thirty or forty years old. They knew this was true because of dates which had been carved on the shells of the turtles. Many turtles live to be very, very old. It is said that the turtles around the Galápagos Islands, which are off the coast of South America, are the oldest living animals today. Some of them are nearly two hundred years old.

Turtles are not able to stand the cold of the northern winters; so they hibernate until warm weather arrives. They do not make burrows like the woodchuck and chipmunk, nor do they hang themselves up like the bat, but they bury them-

American Museum of Natural History

The turtle. Some turtles are among the oldest living animals. Did you ever find one with a date carved on its back?

selves in a place where the frost cannot reach them, near a pond or a stream.

When a turtle is on the land, it walks about with head, legs, and tail outside of its shell. But at the first sign of danger, head, legs, and tail quickly disappear inside the protecting shell. Only the tip of the nose may then be seen. Some sea turtles spend most of their lives in the water.

All turtles lay their eggs on the land. The mother turtles dig holes in the sand along the shore or near the bank of a stream. Then they lay their white eggs in these holes. The eggs are hatched by the sun.

Land turtles eat almost any kind of fresh, tender plants, berries, and earthworms. When they are kept indoors they will eat chopped beef, lettuce, small fruits, and ant eggs.

Some kinds of turtles make interesting pets, but a number of turtles will not live together very peacefully. They may fight. If they are not separated they may eat each others legs and tails; so it is wise to keep only one turtle as a pet.

Do You Know

1. Where to find a woodchuck's burrow?
2. Whether the woodchuck's fur is valuable?
3. Why farmers do not like to have woodchucks on their farms?
4. Why the bat is not a bird?
5. Why the bat is a good friend to man?
6. How the chipmunk carries the loose earth away from his nest?
7. How he stores his food?
8. The best place to sit to eat your lunch when you are hiking or picnicking in a very rocky country? Why?
9. What a turtle's eggs look like?
10. How they are hatched?
11. How reptiles differ from mammals?
12. How often snakes shed their skins?
13. How to tell a poisonous snake?

Things to Do

1. Get a toad, a turtle, a frog, or a garter snake.

2. Keep it indoors in some sort of box or cage. Put some earth on the bottom of the cage.

3. As cold weather comes, place the box in a cool place. What does the animal do when it is cold? What does it do when it is warm?

UNIT IV

Color that Protects

How Some Animals are protected by their Color

COLOR THAT PROTECTS

Were you ever startled when you were picking a leaf or a flower from a plant by finding something that moved under your fingers? It may have been a caterpillar. It may have been a walking stick. Why didn't you notice it until it moved?

You may almost have stepped on a toad or a small snake that was in your path or in the grass. You didn't see it until it moved. Why?

A mother bird sitting quietly in her nest in a tree may often not be seen until she flies away. Why?

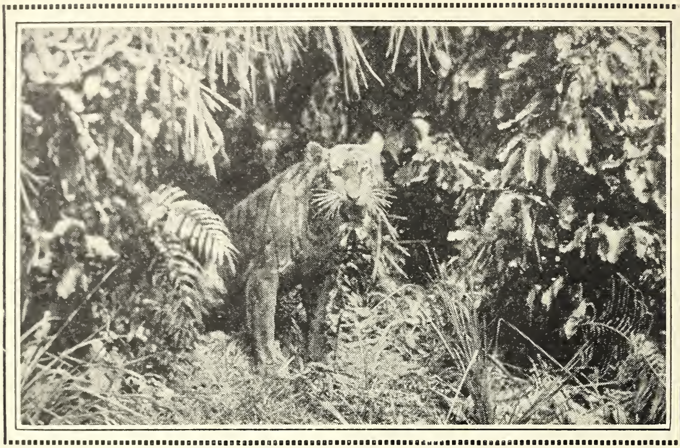
Read Unit IV and you will find that these questions are answered. The story tells you about many animals that have a way of hiding themselves.

Problem · How Some Animals are Protected by their Color

Did you ever try to follow a rabbit that you saw run across a road into some grasses or bushes?

Can you find the rabbit in this picture? How does his color help him?

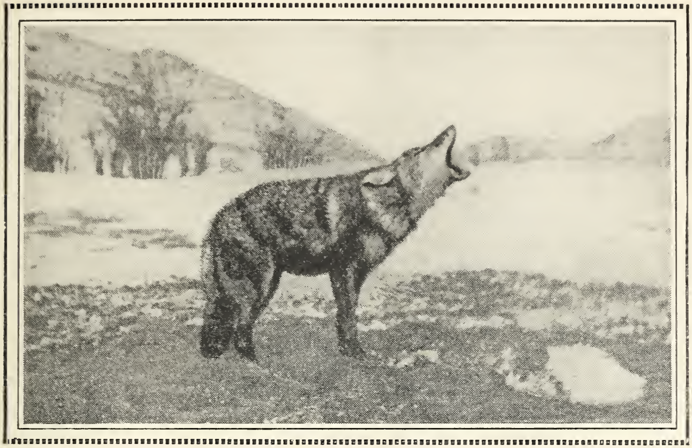
Was it easy to find him? You had to look very carefully in order to see him. His color is like the color of the bushes and grasses into which he ran. The rabbit has another way of hiding himself. He remains very quiet. Unless he moves, he is not seen. When he is chased by other animals, he will run in long leaps into patches of the thorniest bushes he can find.



The tiger's colors are like the colors of the grasses and bushes of his home. Other animals do not often see him

Most animals are in danger all the time of being caught and killed by other animals. But they have ways of protecting themselves. One of the best ways is for them to be covered with colors that are like the colors of the places where they spend most of their time. Some have the colors of the ground. Some have the colors of the trees. Others have the colors of the grasses. The tiger's stripes hide him when he is roaming about among the tall grasses and bushes where he lives, hunting for food.

Some animals have a summer color and a winter color. When winter comes in the Far North the Arctic fox and the ermine become as white as the snow that covers the land. Their white fur makes

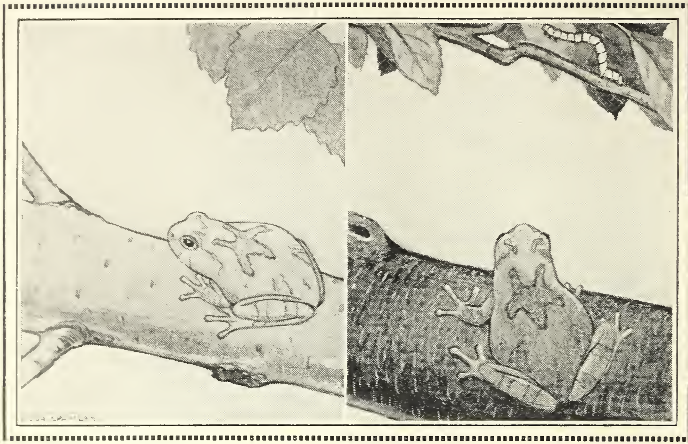


The coyote in its lonely desert home. Why is it crying? What do you think it would find to eat in this desert region?

it difficult for their enemies to see them. In the summer the fur of the Arctic fox is blue-gray. The ermine is reddish-brown on the back and yellow underneath. The tip of its tail is black during the whole year.

Many of the animals that live in and near deserts have the colors of the bare rocks and soil of their surroundings. They are usually dark gray and brown. Bright colors would soon bring danger to these animals.

There are some small animals that have a way of hiding themselves even when you are looking at them. They hide themselves by changing their color so that they look like part of the thing they

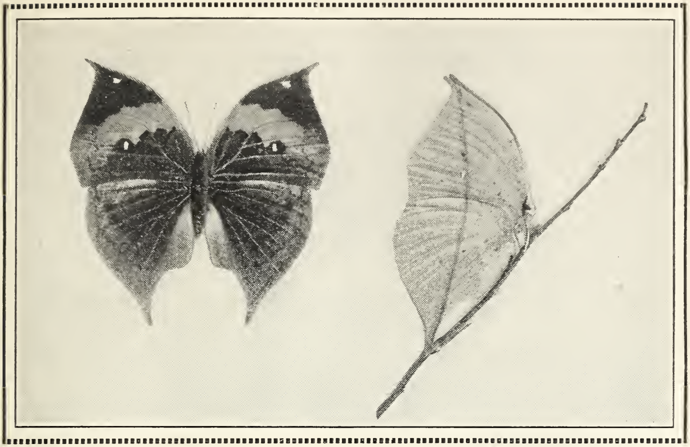


Tree frogs. You have heard these little peepers in the spring. You may not have seen them. Why? Read about them

are on. Their color doesn't change all at once to that of the thing they are sitting on. Sometimes it may take them over an hour to change their color. Tree frogs and chameleons hide in this way.

Did you ever pick a piece of goldenrod and find a small yellow spider hiding among the blossoms? You may not have seen him until he moved. It was the crab spider, and the yellow flower was a splendid hiding place for him. If you put him on a white flower, he will change his color to white.

The animals that change their color in order to protect themselves must remain very, very quiet. If they move, even the least bit, their enemies may see them.



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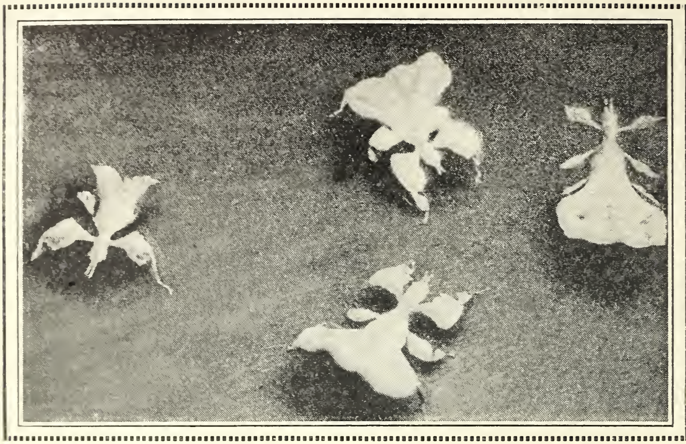
The leaf butterfly. When this butterfly folds its wings above its body, it looks like a dead, brown leaf

Moths and butterflies have many enemies at all times in their lives. They have enemies that eat them when they are eggs. They have enemies that eat them when they are caterpillars. They have enemies that eat them when they are moths and butterflies.

Some moths and butterflies look like the bark of the tree or like the fence on which they are resting. They are not seen until something disturbs them. The lovely green Luna moth often rests all day among the leaves of the trees without being noticed. There are some moths that have bright spots of color on their wings, but these bright spots are often on the underwings. They



This insect is called a walking leaf. Why do you suppose it was given such a name? How does its appearance help it?

are not seen when the moth is resting. The over-wings, which are dull in color, cover them. Leaf butterflies rest with their wings folded above their bodies. Then they look like dead brown leaves, and they are not seen by their enemies.

Caterpillars that are green and brown in color are frequently not seen by birds that are hunting for food. The birds do not see the caterpillars because they look like the grass and the ground.

Walking sticks and walking leaves look much like the twigs and leaves of the plant on which they are found. When these insects are still, it is almost impossible to see them among the branches. So they are called walking sticks and walking leaves.

© W. Lyman Underwood

There is a woodcock in this picture. Can you find him?

There are certain crabs along the shore that have a trick of hiding themselves. They cover their shells with seaweed. Then they are able to walk about in this strange dress and often escape their enemies.

Scientists do not agree as to why some birds have brighter colors than others. Many of our birds do not have bright, gay colors. They have the gray, brown, and green colors of the places in which they live. These colors often hide them from their enemies. The woodcock spends most of its life on the ground. It looks so much like its nesting place that it is almost impossible to see it.

Among some kinds of birds there is a great difference in color between the male and the female. The colors of the males are very bright and gay. Dressed in their gay colors the male birds may be plainly seen as they fly among the trees. The female has important work to do. She must build her nest and must stay in it a long time in order to warm and hatch the eggs. Then she must feed her young. If she wore the bright colors of her mate, she would be easily seen by her enemies.

Animals cannot always depend upon their colors to protect them from all their enemies. The colors that hide them from some enemies may not hide them from others. A great many animals often show their enemies where they are as soon as they move. When they wander about hunting for their food, they often lose their lives; so the habit of keeping still is also very necessary for the protection of many animals.

Things to Do

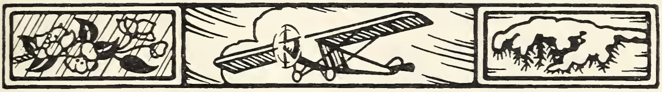
1. See how many animals you know or can find that have the colors of their surroundings.

2. Look for a crab spider on the flowers of the goldenrod. Experiment with it to see if its color changes.

3. List some of the animals you know that do not have the colors of their surroundings.

UNIT V

Weather



What is the Weather?

WEATHER

In the previous units you have been reading about living things. You have learned about the flights of the birds to the north and to the south. You have learned why certain animals dig burrows in the earth and sleep during the winter. You have learned how some of the trees change their color, and why their leaves fall.

In some of the following units you will read about things that are not living, but they are the things without which living things would not be able to stay alive and grow. Some of the stories are about heat, light, and water.

Do you know why we have water on the earth? why we have rain, or snow, or hail?

Do you know how it is possible for us to know when a cold wave is on its way? Why are we able to warn sailors when storms are coming?

After you have read about weather and the Weather Bureau you may know how to answer these questions.

Problem · What is the Weather?

1. What the Weather Does

Everyone thinks about the weather. It decides for us what we do during the day. It decides the kind of clothing we wear each day. It decides the kinds of houses that are built, and many times the kinds of food we eat. The weather is of the greatest importance to the farmer and the fruit-grower. It is of great importance to steamship companies. In fair weather, ships come into port on time after a safe journey; at other times they may be delayed by storms or fog.

It is necessary for engineers who build roads and bridges to know that cold and hot weather make materials such as concrete, iron, and steel contract and expand. The safety of millions of people depends upon the engineers' knowing these things.

2. The Air About Us

Our earth is surrounded by a layer of air many miles thick. We know air is a mixture of gases. It contains nitrogen, oxygen, some carbon dioxide, and a little of several other gases. It also contains water vapor and dust. The dust may have come from smoke, soil, or volcanic ash, or it may be

bacteria or spores (from plants) almost too small to be seen.

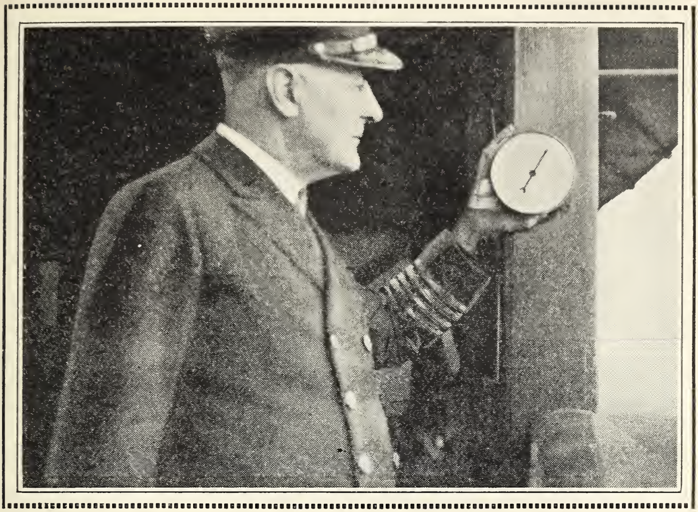
The dust in the atmosphere plays a very important part in our life upon the earth. It forms the center of raindrops and, usually, of snowflakes. It causes the beautiful colors of the sunrise and sunset. The very small bits of dust act as tiny mirrors and reflect the sunlight into many hidden spots and around many corners. The dust also helps to control the amount of heat in our atmosphere.

The water vapor in the air is a gas. The amount of heat which the atmosphere holds depends on this water vapor, as well as on dust. Without water vapor there would be no rain, snow, fog, sleet, hail, dew, or frost. Without it there could be no life upon the earth.

3. Air has Weight

All these gases and the dust which make up the air weigh something, but we are so used to feeling the weight of the air upon us that we do not notice it unless the wind blows. What the air weighs is called air pressure. The air pressure is not always the same. There is an instrument called a barometer which measures the air pressure.

Rapid changes in air pressure bring storms.



An officer on a ship's bridge looking at a barometer. Do you see the barometer?

When warm, moist air comes in contact with cold air, the water vapor, or moisture, forms so that it can be seen; when it does this, we say that it condenses. It forms on the tiny bits of dust in the atmosphere, and it falls as rain or snow. Sometimes the drops may be so small and light that they do not fall, but hang like a cloud near the earth. This is fog.

Warm air holds more water vapor than cold air. We see our breath in cold weather. When the warm, moist breath comes in contact with the cold air it is cooled, and the water vapor condenses. It

© Keystone View Co.

These people are riding through a fog. Think of a reason why driving or sailing in a dense fog may be dangerous. Are aviators helped or hindered by fog?

often clings to collars or mufflers. The same thing happens when fog, rain, or snow is formed. The warm air is cooled rapidly, and water vapor condenses.

All over our earth are places from a hundred to a thousand miles across where there are great masses of very warm air. There are other places where there are great masses of cold air. These masses of warm air and cold air are constantly changing places. The warm air with its load of water vapor is pushed up by the cold air, which

takes its place. When the warm air rises it is cooled, and the water vapor condenses. Clouds are formed, and the moisture falls as rain, snow, or hail.

The moisture may pass through a number of currents of air before reaching the earth. These currents of air may be warm or cold or both. If the air currents are all warm, moisture falls as rain. If they are very cold, moisture falls as snow or possibly as sleet or hail.

Some of this water at length returns to the air by evaporation, and the whole process takes place again. The water that evaporates here may fall with other moisture in some other part of the country many miles away.

4. What is the Wind?

Wind is caused by the air's flowing from a place where the air pressure is great to a place of less air pressure.

If one great mass of air is very warm and a mass of air near it is very cold, they will change places rapidly. The wind will be strong. If these masses of air have nearly the same temperature, they will change places slowly. The wind at such a time will be gentle.

Can you remember a very windy day?

What was the weather at the time?

Notice the kind of weather when the wind is gentle.

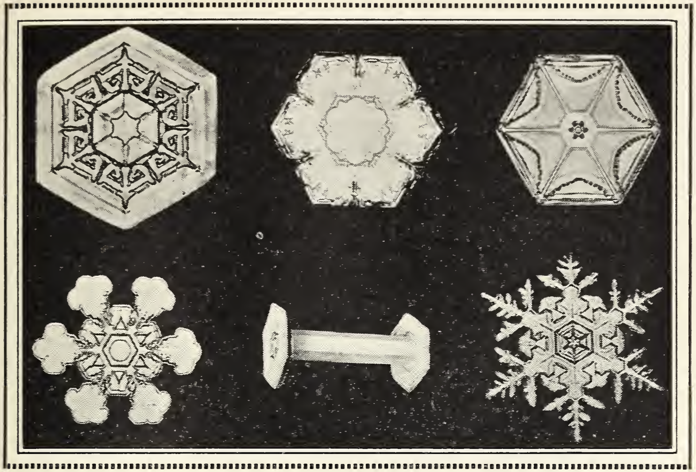
5. Heat makes a Difference in Air Pressure

The earth warms the air more in some places than in others. Sometimes the air is cooled a great deal by the earth, especially where there are long nights and great fields of snow, as in the Arctic country. In these places the cold seems to pile up. The air above such places is sure to be very cold. This uneven warming and cooling of the air makes it weigh more in some places than in others.

6. How Snow is Made

Snow is not made just as rain is made. Snow is formed bit by bit in a freezing temperature. One tiny crystal is added to another until the snow-flake falls. The snow acts like a blanket for the earth. The snow protects the plants and soil from sudden freezing and thawing. Such sudden changes often kill or injure plants.

In the late winter and early spring, as the frost leaves the ground, some of the water from the melting snow soaks into the earth. By the time the snow has disappeared, the frost is gone, and the grass and other plants are putting forth new green shoots.



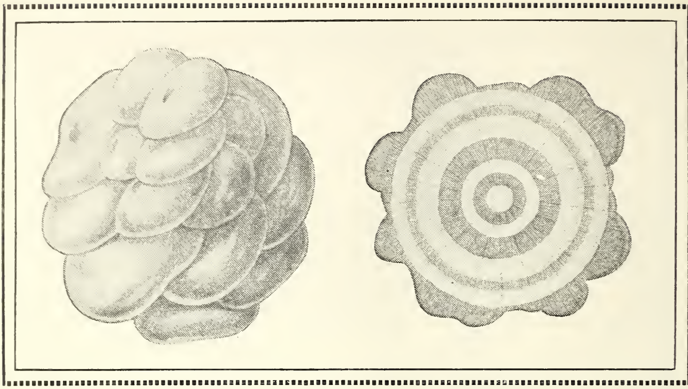
Pictures of snow crystals. These are only a few of the beautiful shapes of snow crystals. You may have seen many others

7. What is Sleet?

Sleet may be raindrops which have been frozen or snowflakes partly melted and frozen again. This happens when raindrops or snowflakes fall through layers of warm and then very cold air near the earth.

8. Hail

Hail is not like sleet. It usually hails only in spring and summer during extremely hot weather. After the water vapor has formed into raindrops, they are carried swiftly up by currents of hot air into places of icy air. There they are quickly

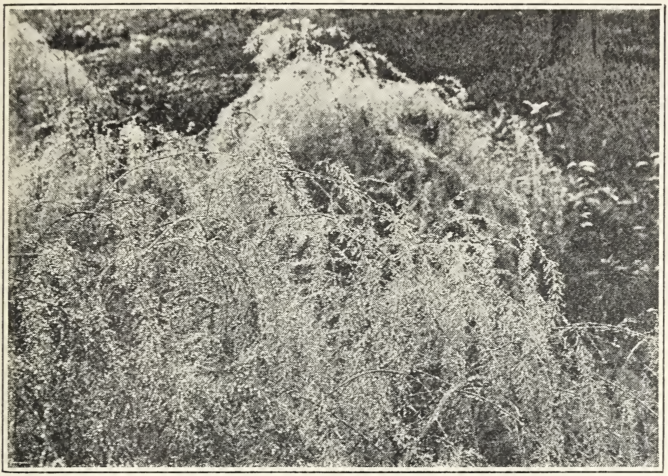


Hailstones. On the right a hailstone has been cut in half

mixed with snowflakes and frozen, making a cloudy layer of ice. In this way little hailstones are formed. A hailstone may fall until it reaches another current of warm air, where it gathers some moisture and is rushed up to icy cold air again. It may be tossed back and forth many times. Examine a hailstone, when possible, and notice the layers of cloudy ice and clear ice.

9. Dew

Dew is more familiar to us than hail is. It often wets our shoes in the early evening in the country. Dew does not fall. It is formed where it is found. It happens like this: At night the earth becomes cooler than the air. Dew forms when objects on



Dew on asparagus plants. The weight of the dew makes the plants bend over

the earth get so cool that the water vapor in the air condenses.

The same thing happens to a glass of ice water on a hot, moist day in summer. In both cases the water vapor in the air condenses.

Grass cools much more quickly than a rock. Dew is therefore found on grass earlier in the evening than on rock.

10. Frost

Frost is formed much as dew is formed. We find frost in places where dew is found, but it is

formed when the temperature is at or below 32° F. As the water vapor in the air condenses, it is so cold that tiny crystals are formed instead of tiny drops of water. Then we have frost instead of dew.

11. Thunderstorms

Thunderstorms come most often in the summer. We may expect one when it is very, very hot and the air is quiet and there is much water vapor in the air. The hot air from near the earth's surface quickly rises. As the hot air rises, it expands and cools. Its load of water vapor condenses, and masses of clouds appear. Rain or hail may fall.

During thunderstorms there are always flashes of lightning and claps of thunder.

Electricity is always present in the air. Every tiny bit, or particle, of dust or water in the air carries a tiny amount of electricity called a charge. These tiny charges are of two kinds. Some are positive charges, and some are negative. When very great amounts of these two kinds get near each other there is a flash of lightning. It is believed that lightning makes the air about it so very hot and disturbs the atmosphere so much that waves of sound are made. The air expands so suddenly that this expansion is like an explosion. The sound which it makes we call thunder.

© R. H. Robins

A picture of flashes of lightning zigzagging through the sky

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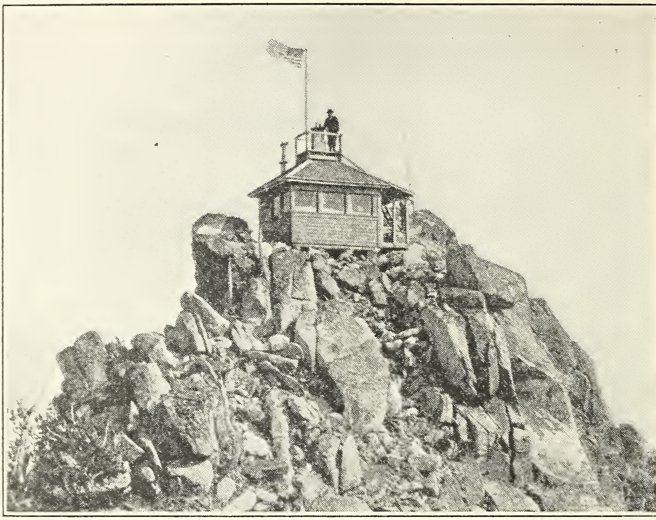


A weather station on the top of a mountain. How should you like to climb to this station? Why is this a good place for a weather station?

12. The Weather Bureau

There are men all over the country who are trained to watch the weather carefully. The places where the weather is watched are called weather stations. They may be on the tops of mountains, in the valleys, or in very dry parts of the country. At these stations several things about the weather are measured. Here is a list of them:

1. The direction and speed of the wind.
2. The air pressure at different times during the day.
3. The temperature at different hours during the day.

4. The amount of moisture that falls during the day.
5. The state of the weather; that is, whether it is fair, cloudy, very cloudy, or only partly cloudy.

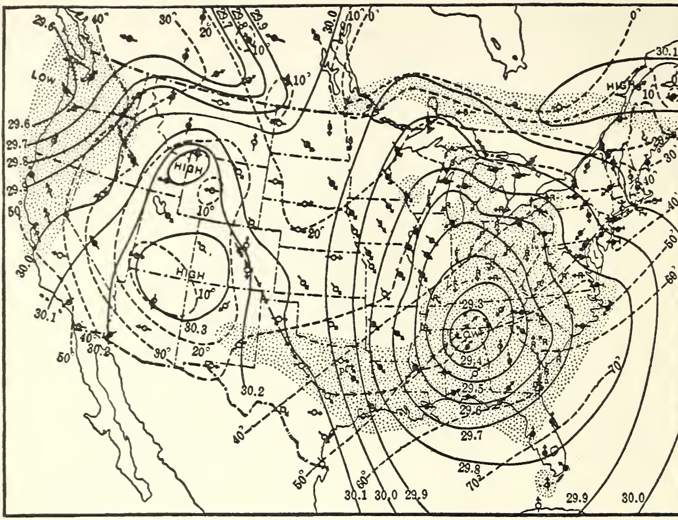
When a record has been made it is immediately sent to a larger station. Then a report is sent by telegraph to the United States Weather Bureau at Washington, D.C.

The reports are sent in code. Can you tell why?

As the reports come in from the smaller stations, they are recorded on a large map. At the Weather Bureau there are men who have carefully studied what causes certain kinds of weather. When they look at the weather maps, they are able to forecast, or tell several days ahead of time, what the weather will be.

Morning and evening forecasts are made in Washington, D.C., Chicago, Denver, San Francisco, and New Orleans. Weather maps are sent out from about fifty of the larger stations. The weather forecasts are mailed to many people, and they can be heard over the radio.

The Weather Bureau warns of floods, high winds, frosts, and other weather that might cause damage. Snowfall is measured, and the amount of water that will come from it is told ahead of time. Some cities depend upon the snow that falls for their water supply. Do you think of anyone else who would be interested in the amount of snow



Here is a weather map that was made for January 5, 1931, at 8 A.M. Do you know what high and low on this map mean?

that falls? Do you think of anyone who would be interested in the direction and speed of the wind?

Before Lindbergh started on his long flight across the ocean, he examined weather records, not only of America, but also of the ocean over which he expected to travel. They were his best guide as to the time that would be most favorable for his trip.

All aviators who fly long distances keep in close touch with the forecasts of the weather stations.

Have you ever happened to tune in on your radio and heard the aviation weather forecasts?

These reports may not mean much to you, but aviators listen to them carefully.

Things to Think About

1. The list of industries that weather affects is very long. Name some of them.

2. In what way does weather affect these industries?

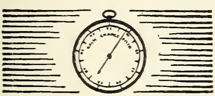
3. How does the weather affect you on a sunny day? on a stormy day? on a cold day? on a hot day?

4. Why must the Eskimo's house differ from your house? from the kind of house the people need who live within the tropics?

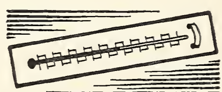
5. In what way does the weather decide the kind of food that you eat? the clothing that you wear?

6. How many pounds to the square inch is the air pressure near the surface of the earth?

7. How does the air pressure change away from the earth's surface?



Things to Do



1. Write to the United States Weather Bureau at Washington, D.C., and ask them to put your name on their mailing list for daily weather maps.

2. Learn to read a weather map.

3. Find out what is meant by a low; by a high. Find out what the lines on the map mean.

4. Find out where the weather station nearest your home is located.

UNIT VI

What are Magnetism and Electricity?

1. Magnets
2. Compasses
3. Electromagnets
4. Electricity caused by Friction

WHAT ARE MAGNETISM AND ELECTRICITY?

You probably have played with horseshoe magnets and have seen how they attract, or pick up, many things. These horseshoe magnets are straight bars of steel that have been bent into the shape of a horseshoe. Bar magnets are straight bars of steel that have not been bent.

All these magnets are sometimes called artificial magnets because they were made by man, not by nature.

In the next problem you will learn how man makes magnets. Some experiments are given that you may like to try. You will also learn about magnets that are not made by man.

Magnets that are not made by man are spoken of as natural magnets or lodestones. Lodestones, or leading stones, as they are sometimes called, are scattered about the earth. They look much like ordinary rock. They have a certain kind of iron ore, magnetite, in them. You will find a lot about them in the next problem.

Compasses are very useful to airmen and seamen today. Do you know how to make and use a compass? Problem 2 will tell you how this is done.

No doubt you have made electricity by rubbing certain objects together. What kind of electricity did you make? In how many different ways have you made this kind of electricity? This unit will help you to learn a great deal about magnetism and electricity.

Problem 1 · Magnets

1. How Magnets got their Names

We do not know just when or how natural magnets were discovered, nor do we know just how these lodestones received the name of *magnets.* One story is told of how these stones were discovered in the country of Magnesia, in Asia Minor. Another story that comes down to us is that the word *magnet* came from the name of a shepherd boy called Magnes. While watching his sheep he noticed that his shepherd's iron crook stuck to the side of a rock. He also saw that the nails in his sandals were attracted by the rock. The Chinese knew about lodestones and used them for compasses long before the time of Magnes. The old records of the Hebrews and the Romans show that lodestones were used by them too.

In ancient days men did not experiment as they do today. They believed that magnets were some kind of magic stones. Many tales were told about the strange power which the iron ore contained. One of these tales is about a ship which was wrecked because all its nails were pulled out by a huge mountain of iron ore.

About three hundred years ago a man by the name of Gilbert made the first important experi-

Magnes and his sheep. When his iron crook touched the rock, something happened. Do you know what did happen? The story tells you about it

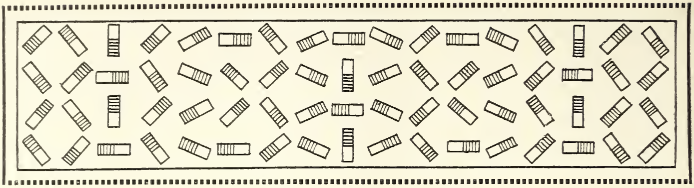
ments with the action of artificial and natural magnets. Even today we are still experimenting with magnets, as is shown in such inventions as the telephone, telegraph, and radio.

2. What makes a Magnet Work

No one knows just what is the cause of magnetism. Here is an explanation which will help us to understand it. All objects are made up of tiny particles. They are very, very small, so small that you cannot see them. These tiny particles are called molecules. Each molecule of steel and iron is a little magnet, with a north and a south pole. These magnets are so tiny they cannot be seen even with a microscope.

If steel and iron contain little magnets, you would think that all pieces of steel and iron would act as magnets, or, as we say, be magnetized. This is not true. Whether or not the steel will be a magnet depends upon the way in which these little molecules arrange themselves inside the steel itself. In the pictures on pages 116 and 117 you will see how the molecules, or small magnets, look in a piece of steel that is not magnetized and in another piece that is magnetized.

The small bars represent the molecules. In the piece of steel that is not magnetized, you can

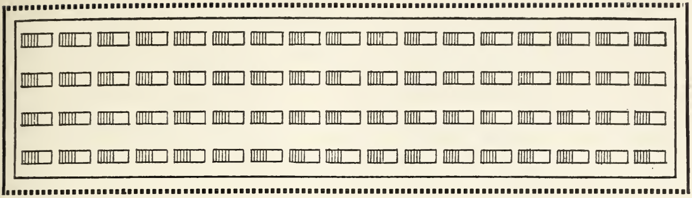


The way molecules may be arranged in an unmagnetized bar of steel

see how the molecules form many little groups because the north pole of one is drawn toward the south pole of another. They seem to be in no particular order. These molecules can be drawn apart by the power of a magnet, and then they will rearrange themselves as you see in the other picture. They form lines all pointing in one direction. The steel bar now has a north pole at one end and a south pole at the other. It has become a magnet; we say that it is magnetized. It will attract or repel other magnets. (Two magnets repel each other when they force each other apart.)

In the picture of the piece of steel that is not a magnet, the small groups formed by the little north and south poles are pointing in different directions, and that is why the steel is not magnetized.

In the other picture all the molecules have so arranged themselves that their north-pole ends are all pointing in one direction and their south-pole ends are all pointing in the opposite direction.



The way molecules may be arranged in a magnetized bar of steel

This is always true of a magnet. One end of it is the north pole. The other end is the south pole. Even though you can see no difference between the two bars of steel, they are different, and it is all because of these tiny molecules inside the bars.

If a piece of steel is heated very hot, these little molecules will not form lines like those you see in the picture of the magnetized steel. They will arrange themselves as in the other picture. There will not be any poles, and the piece of steel will not be a magnet. Try heating a magnet for a long time, and then see if it can still attract steel or iron. Your steel will be dead so far as any magnetism is concerned.

If you break a bar magnet into parts, each part becomes a real bar magnet, with a north pole and a south pole that will attract and repel. The middle of a bar magnet does not have so much strength as the poles.

Iron and steel are "magnetic substances" because they can be attracted by a magnet.

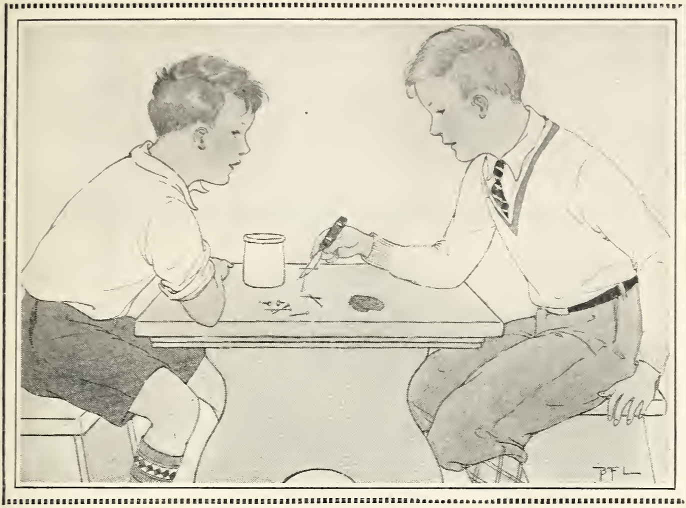
Many substances are not attracted by magnets. Try picking up wood, rubber bands, cloth, or a gold ring with a magnet. Will they cling to the magnet? They will not become magnetized by the magnet. This is a good thing, for our world might be quite different if all things were good "magnetic substances."

3. Experimenting with Magnets

There is much fun in playing with magnets. Other children have done some experiments which helped them to learn more about the great force called magnetism.

They experimented to see whether a lodestone would magnetize a piece of steel. First they stroked the steel with the lodestone, stroking from the center out. They were careful to stroke it the same way each time. It soon became magnetized and picked up other pieces of steel.

These same children also magnetized a knife blade in this way. They used the magnetized knife blade to pick up small nails and tacks. Children are not the only persons who use magnetic power in this way. Men have invented magnetic hammers to assist them in their work. These hammers are used for picking up and holding nails and tacks. Men are able to drive many more nails with this help.



Ned and his friend Tom magnetized the blade of a jackknife with a lodestone. What are they trying to do with the knife?

Stroking the steel blade with the lodestone made the little particles inside the blade rearrange themselves. These molecules were all helter-skelter at first, but as the lodestone passed over them they changed positions so that their north poles all pointed in the same direction and their south poles all pointed in the opposite direction.

Another interesting experiment which the children did was to lay two bar magnets down beside each other. First they put the north poles of both magnets together. Do you think the magnets stuck together? Then they put the north pole of

one magnet next to the south pole of the other magnet. They were surprised to notice that these two different, or unlike, poles clung together, or attracted each other.

4. How far can a Magnet Attract?

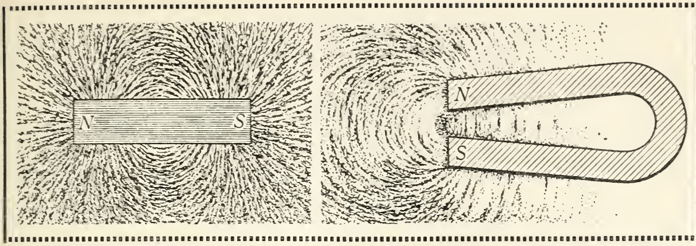
When farmers turn their cattle out to pasture, they usually put them into fields which are set off from the rest of the farm by fences. The cattle can go anywhere within the fields to eat, but they cannot go beyond the edges of the fields because of the fences.

Magnets have fields, too. These fields have no fences around them as the cow pastures have, but they are fields, all the same.

The field surrounds the magnet. It is the space about the magnet within which iron and steel are attracted to the magnet. We call it the magnetic field.

A very strong magnet has a larger magnetic field than a weak magnet. It can attract objects farther away from it. The objects that a magnet attracts are always in the magnetic field of that magnet.

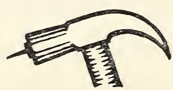
Let us see if we can find the size of the magnetic field of a magnet. Lay a magnet on the table. Place a piece of cardboard or a piece of glass over



The magnetic field is shown at each pole of the bar magnet at the left. At the right a horseshoe magnet and iron filings are used to show the magnetic field

it. Now sprinkle small tacks or iron filings on top of the cardboard. Tap the cardboard gently. The tacks or iron filings will arrange themselves in lines on the cardboard. These lines are crowded together near the poles of the magnet. Do you see that some of the tacks are outside the magnetic field of the poles? They are too far away to be attracted by the magnet. It hasn't power enough to pull them into its field.

Things to Think About



1. Do the north poles of magnets attract each other?
2. Do the south poles of magnets attract each other?
3. Will the north pole of one magnet attract the south pole of another?
4. Explain what is meant by the statement "Unlike poles attract; like poles repel."
5. What is meant by *magnetic field*?

Problem 2 · Compasses

1. The Magnet as Compass

Perhaps you have never thought that a compass is a magnet, but that is what it is. The needle which points north and south in a compass is a small bar magnet which swings on a pivot. The glass is used only as a protection for the delicate needle inside.

The Chinese are supposed to have discovered that magnets could be used for compasses. However, the Arabs, the Greeks, the Finns, and the Italians have also claimed to be the discoverers. No one knows who did make the discovery.

During the thirteenth century compasses were used to guide the ships on the Mediterranean Sea. Goods were carried from the east to the west, and sailors found compasses very useful. Long voyages were seldom attempted before the compass was invented. The compass aided Columbus very much in his voyages of discovery.

Compasses are of great value to seamen today. They help sailors to go in the right direction. Sometimes the steel and iron in a ship cause the compass not to work. Carry a pocket compass when you go on a hike. It will help you to find the north.

2. How to Make a Compass

Since you already know that unlike poles attract each other and like poles repel each other, it will be interesting for you to make a compass. This is one way to make one.

Use a bar magnet with the poles marked on it. Hang the bar magnet by a string in such a position that it will be free to swing in the air. It should point north and south when it comes to rest.

Another very easy, and even more interesting, way of making a compass is with a cork and a needle. Magnetize an ordinary needle by stroking it on a magnet. Stroke it each time in the same direction, from the center outward. Either pole of the magnet may be used, but be sure to stroke the needle on the same pole each time.

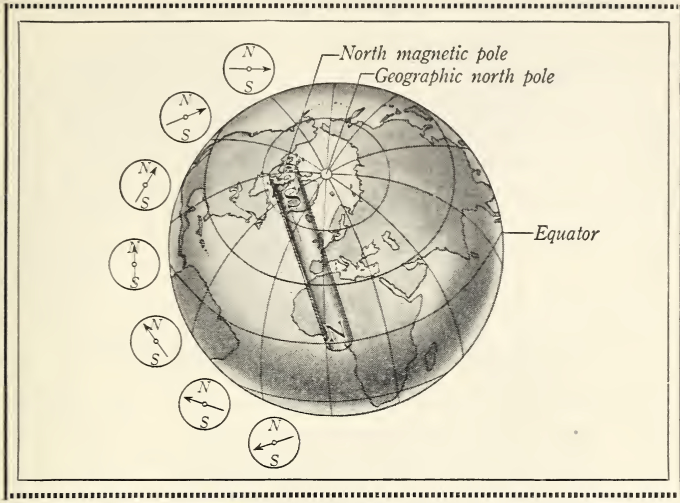
Test the needle with some small tacks or iron filings to see if it has become magnetized. If it is not strong enough, stroke it against the real magnet again.

Stick the magnetized needle through a cork. Place the cork and needle in a pan of water. The needle should soon point north and south. Do not have the pan too small, or your compass may not work. Sometimes pans are coated with tin and have iron underneath. This will affect the magnetic needle of the compass.

Joan, Ned, and Tom magnetized a needle and stuck it through a cork. Why did they put the cork and needle in the pan of water? What should the needle do?

One end of the needle will point in the direction of north. That is why we call it the north-seeking pole. The other end of the needle will point toward the south, and it is known as the south-seeking pole.

Look on your bar magnet. The *N* stands for the north-seeking pole, the *S* for the south-seeking pole. You will sometimes hear them called north and south poles, but you know now that they are really the north-seeking and south-seeking poles of the magnet. You find the poles at the ends of the bar magnet.

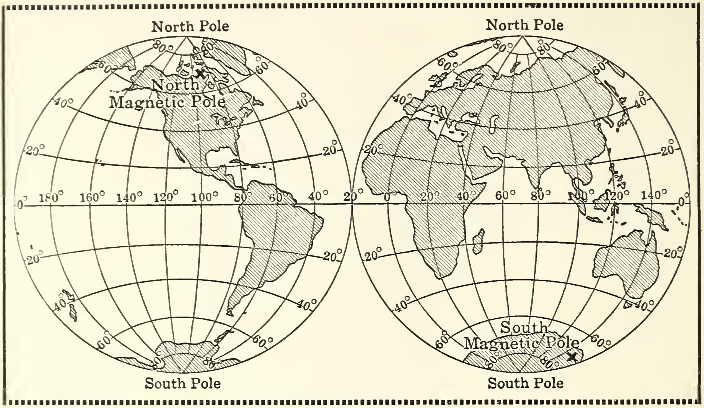


The needles of magnetic compasses act as if the earth had a core of iron and nickel inside of it, with a south pole near the Hudson Bay and a north pole in the Antarctic

3. The Earth is a Huge Magnet

The reason that compasses point north and south is that the earth itself is a huge magnet with two magnetic poles, a north magnetic pole and a south magnetic pole. These magnetic poles are not the same as the north and south poles you have read of in your geography books. The north magnetic pole is near Hudson Bay, about twelve hundred miles from the true north pole. The true poles you read of in your geography are also called geographical poles.

The earth is a very large magnet. It is so



On this map of the world find the north and south magnetic poles. Find the true north and south poles

strong that its magnetic field reaches over the whole earth itself. Even when a compass is several thousand miles from the poles, the needle will point to them.

Sir James Ross discovered the north magnetic pole in 1831. The south magnetic pole is in the Antarctic. It was discovered by Shackleton during his expedition in 1907 to 1909. The explorers found that the magnetic poles looked quite like the rest of the country around them.

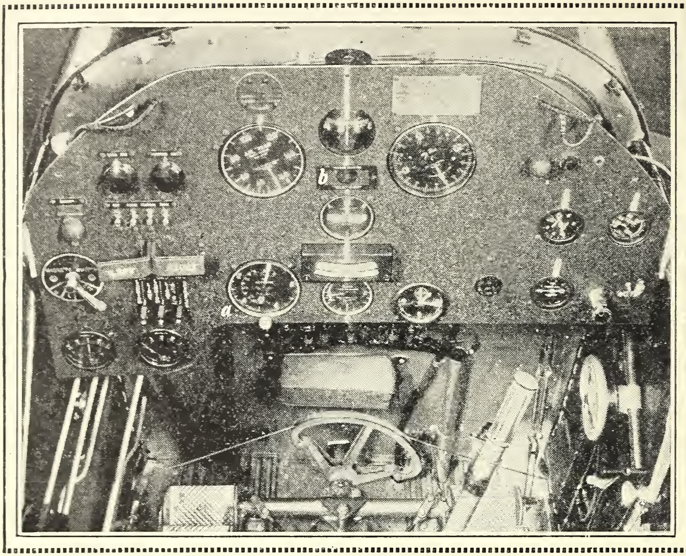
Scientists do not know exactly why the earth is a magnet. Some think that the iron deposits of the earth have become magnetized and have caused these magnetic poles. Others think that the rapid rotation of the earth has brought about

a magnetic state. Still others believe that the sun is responsible for the magnetic state of the earth.

The nearer a compass is brought to one of the magnetic poles, the more one end of the needle that can swing up and down tips to the ground. When it reaches one of the poles, one end of the needle points straight down.

On most places of the earth the compass does not point to the true north because it points toward the magnetic pole. You probably have read of ships sailing *due* north or *due* south. This means that they are sailing toward the true north pole or the true south pole, not toward the magnetic north pole or the magnetic south pole.

When compasses were first made, people did not know why they always pointed in the same direction. They noticed that compasses did not always point to the true north, but they knew nothing of the earth's magnetic pole. We are told that the sailors who made the voyage with Columbus were worried because the compass did not point due north. Columbus explained to them that the changing of the North Star was the cause of this and so satisfied them. Of course we know now that this is not true. We know that the magnetic poles are responsible for this difference. This difference has been found out for all places



The instrument board of an airplane (*a*, altimeter; *b*, compass)

on the earth, and so ship captains may know at any place where the true north is.

The compass is especially valuable to sailors. They need it because there are no roads through the sea that can be seen, and they must find their direction by means of compasses.

People driving in automobiles follow roads and signposts. They do not need to use a compass to get their directions. But what of aviators who are flying through the air? Do they have air roads and signposts to follow? They have to find their direction mainly by the use of compasses.

Things to Think About

1. Why doesn't the compass point to the true north?

2. What is the difference between the north pole and the north magnetic pole?

3. Where on the earth's surface will one end of a magnetic needle point straight down?

4. What is meant by "due north" and "due south" on the earth and on maps?

5. What people must depend very largely on the compass to guide them? Why?

6. Does your compass point in the direction of the North Star?

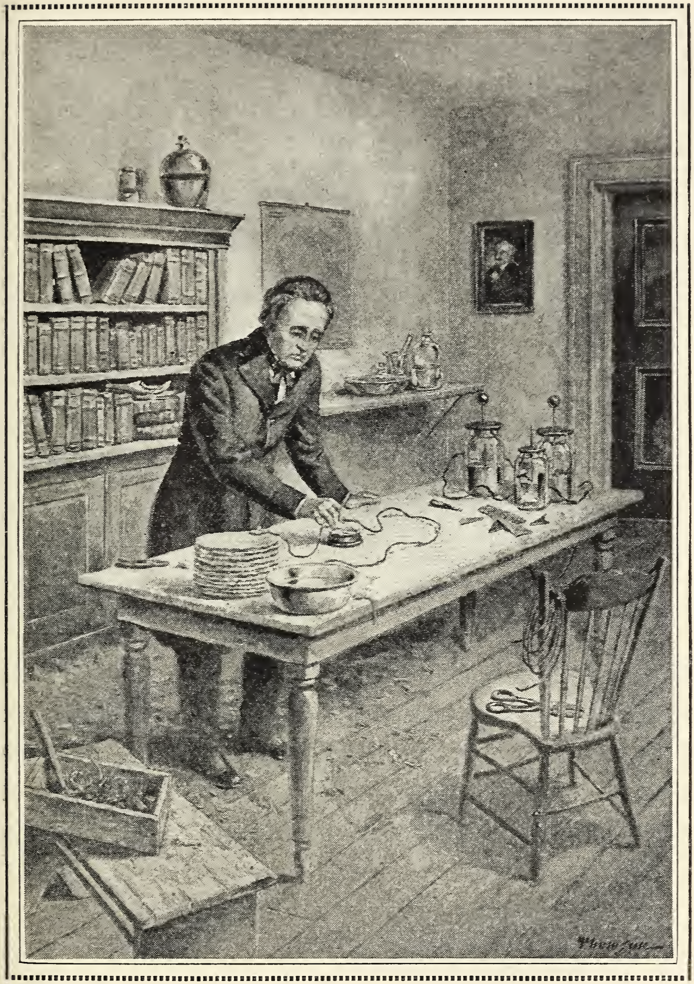
Problem 3 · Electromagnets

1. Electricity and Magnetism

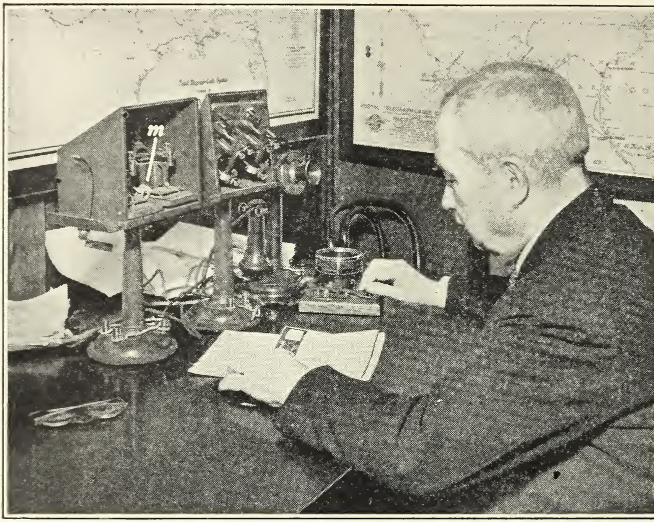
You have been reading about two kinds of magnets. One kind is the artificial magnets, made by man. The other kind is the natural magnets, which are scattered about the earth and which look like any ordinary rock. In fact, the earth itself is a huge magnet, and we live in its magnetic field, as you have learned.

There is another kind of man-made, or artificial, magnet, which does many things for us. It makes our doorbells ring. It helps us to talk over the telephone and to send telegrams. It also makes the radio possible. Let us learn about this new kind of magnet.

One day a little more than a hundred years ago a scientist named Oersted was working in his laboratory in Denmark. He was performing some experiments with electricity. Accidentally a compass was brought near the electric current. When this was done, Oersted noticed a very strange thing. He saw the needle of the compass move. He became so interested in the action of the compass needle that he stopped the experiment he was working upon and began to watch the compass. When the compass was brought near the wire



Oersted makes the important discovery that a wire carrying an electric current acts like a magnet. The story tells how he made this discovery



Why are electromagnets used in the things you see on the table? (*m* points to one magnet)

through which there was an electric current, the needle of the compass moved. This showed Oersted that an electric current affected the compass. He was the first to discover that a wire carrying an electric current acts like a magnet.

2. How to make an Electromagnet

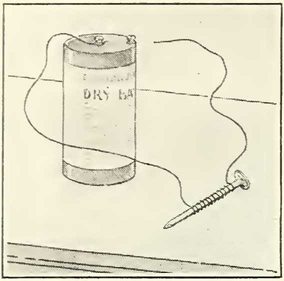
To make an electromagnet you will need a dry cell, some bell wire, and a piece of iron, such as a nail or spike. Wind the wire carefully around the nail. Fasten the ends of the wire to the dry cell.

Ned and Tom are making an electromagnet with a dry cell and some bell wire wrapped around a nail. You might like to make one, too

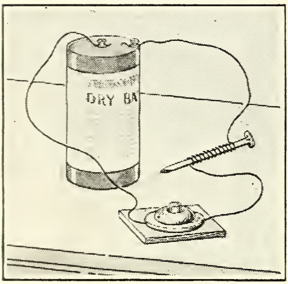
Be sure to remove the insulation from the ends of the bell wire before connecting them to the posts of the dry cell. Scrape each end carefully. Now dip the end of the nail or spike into some tacks, paper clips, or needles. What happens?

You have made a circuit through which the electric current can flow. The current of electricity has magnetized the iron bar. You have made an electromagnet.

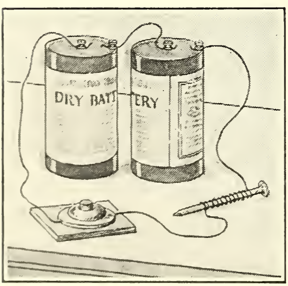
This electromagnet is very useful because it can be turned off and on at will. Break the circuit



A broken circuit because one of the wires is not connected with the dry cell



Here the magnet is wired to a push button



The strength of the electromagnet is increased by using two dry cells

by disconnecting one of the wires from the dry cell. The electromagnet no longer attracts the tacks. You have an ordinary piece of iron and a piece of wire.

You may want to wire the magnet to a push button so that you can make and break the electric circuit more easily. The picture shows you how.

The strength of an electromagnet can be changed by changing the current. If the electric current is made stronger, the electromagnet will be stronger. Try making a stronger magnet by adding another cell.

When radios first came to be used, electromagnets were not yet used for loudspeakers. Now, with the use of electromagnets, the tones can be made loud or soft.

Huge electromagnets are

This is a picture of a very powerful electromagnet. It is used for lifting heavy objects. What gives this electromagnet its great strength?

used where heavy lifting is necessary. Great pieces of steel or iron can be moved by the use of electromagnets. The stronger the current, the more the electromagnet can lift.

Problem 4 · Electricity caused by Friction

Electricity can be made by friction, or by rubbing two things together. Just rubbing any two objects together will not always make electricity; but when certain objects are rubbed against certain other objects, electricity is formed. Electricity, formed by rubbing two objects together, is called frictional electricity.

Frictional electricity has probably surprised you many times. Have you ever had your hair snap and crack when you were combing it? Did it ever "stand on end" as you pulled the comb through it? This all happens because of frictional electricity. The comb rubbing against the hair forms electricity.

Have you ever walked across a rug on the floor and touched a radiator, a bed, or some other metal object and then jumped because you received a small electric shock? If so, you know how frictional electricity feels.

There are other ways of making frictional electricity. Tear up a piece of paper in tiny bits. Now rub your fountain pen across your woolen sweater or coat. Hold the pen near the bits of paper. What happens? Rubbing the hard-rubber pen against the woolen sweater causes frictional electricity.

When this Greek was polishing a piece of amber, he discovered that it attracted certain objects. He discovered frictional electricity

D

Rub a glass rod with a piece of silk. Hold the glass rod near the paper. What happens now? Rubbing glass with silk also causes frictional electricity.

Sometimes when you are writing at your desk you may lift your arm, and the paper will stick to your sleeve. This is due to frictional electricity.

The Greeks discovered electricity over two thousand years ago. They were very fond of amber. We use amber to make into beads. As they rubbed the amber to polish it they noticed that it attracted certain objects. Our word "electricity" came from *electron,* which is the Greek word for amber.

Frictional electricity is different from the magnetism that you have been reading about. First of all, it is made by rubbing objects together. When you magnetize a needle, you use a magnet, stroking the needle from the center outward. Frictional electricity will not last. It does not stay in objects so long as magnetism stays in a bar magnet.

Electricity made in this way is called frictional electricity or static electricity because the objects which make it do not carry it. A glass rod, a comb, or a fountain pen will not *conduct* electricity. Copper wire, steel, or iron all conduct electricity, that is, let it flow through them. They are called conductors of electricity, but glass and rubber are called nonconductors.

Many scientists have worked with frictional electricity. Benjamin Franklin experimented with it. He wanted to prove that lightning was electricity. He used a silk kite and tied a key to the end of the kite string. When there was a flash of lightning he got a shock from the key. The electricity had come down from the kite into the key.

You have already learned something about lightning and thunder in the unit on weather. Lightning is the passing of electricity from cloud to cloud or from a cloud to the earth in such a way as to make a giant spark. It is like the spark secured from stroking a cat's fur, except that it is many times greater.

Very few people are ever hurt by lightning. However, it is wise to know a few things about where to go during an electrical storm, or thunderstorm. One is safer indoors than outdoors. It is a good plan to keep all windows and doors closed during the storm. If you are caught outdoors, you should avoid standing under trees, because they make good paths by which lightning can pass down into the moist earth. Tall trees are especially dangerous in a storm.

In the Arctic regions the sky during long winter nights is sometimes lighted by northern lights, or aurora borealis. Sometimes colored lights shoot

up; at other times great curtains of beautiful colors seem to cover the sky. The Antarctic continent has an aurora, too; but the beautiful colors and lights are called southern lights. The exact cause of auroras is not known. However, scientists feel sure that magnetism and electricity have something to do with them. They also know that the auroras are very high in the air that surrounds the earth.

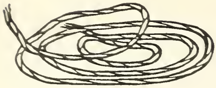
It is thought that the huge spots on the sun (about which you will read later in this book) have something to do with the auroras. These sun spots are really huge magnets with north and south poles. There are usually brilliant auroras during the times when there are many of these spots on the sun. The earth's magnetic field, too, may have something to do with them.

Scientists are studying auroras all the time. Polar trips, such as those made by Peary and Byrd, help scientists in their studies. Some day we shall know more about the real cause of auroras.

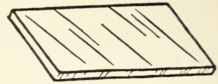
Things to Think About

1. Why does thunder do no damage?
2. Why are lightning rods sometimes used?
3. Why should one never stand under a tree during an electrical storm?

The aurora borealis is often seen in the Arctic and Antarctic regions



Things to Do



1. List some of the ways not given in this problem by which you have made frictional electricity.

2. Other people besides the Greeks experimented with frictional electricity. See if you can find out who they were.

3. Make a list of the things you know that are conductors of electricity.

4. List the things you know that are nonconductors.

5. Find out other ways in which Benjamin Franklin experimented with electricity.

6. Find out why frictional electricity isn't widely used today.

7. Find out what causes "static" in the radio.

UNIT VII

The Sky

1. Stars
2. The Sun, our Nearest Star
3. The Solar System
4. The Story of the Moon

THE SKY

People have always wondered about the things, or bodies, in the sky. Some thought they were gods and goddesses. Others thought they were small lights just a few miles above the earth. One little girl said they were holes in the sky. What do you think they are?

There are many different kinds of bodies in the sky. Some are giants which are many times larger than our sun. Some appear to be tiny bodies, so small that even astronomers, who study the sky with huge telescopes, can scarcely tell they are there.

The moon is our nearest neighbor. It is so near that we can make out the huge valleys and mountains on its face. Why do we see only one side of the moon?

The comets are strange bodies. They come and go. Where do they go? Why do they come back?

In the next unit we shall make a journey through the solar system and take a look into the universe. Perhaps we can find an answer to some of these questions in this unit.

Problem 1 · Stars

1. What are Stars?

Should you care to count the number of stars you see in the heavens on a clear night when there is no moon to make the world bright? You would soon grow very tired, for you can see about two thousand stars with your naked eye. There are millions and millions of other stars, but they are so far away that you would need a telescope to see them. Even the number that may be seen through telescopes grows larger and larger; for as scientists make improvements in telescopes, they see more stars.

Have you ever been to the seashore? How should you like to count the grains of sand you sat upon and played upon? One scientist says that there may be as many stars as there are grains of sand along all the shores of all oceans of the world. Think of the tremendous number that would make! He also says that these stars are always wandering about in space. A few of them travel in groups, but most of them wander all alone. The universe is so very great that the stars travel on and on and may never come anywhere near each other.

Every star that you see in the heavens at night

Joan and Ned looking at the stars. What stars do you think they are trying to find?

is a sun. Every one of them is so very hot that no living thing could remain alive on them for a second. Some of them look like tiny specks of light in the sky, but they are really enormous in size. Scientists tell us that a very few of them are just a little bigger than the earth, but some of them are big enough to hold hundreds of thousands of earths, with plenty of room left. Sometimes we find a star that is a huge giant. Millions of millions of earths could be put inside it.

You may have noticed that some stars seem to be much brighter than others. You probably

thought that the brighter ones were much larger than the others. This may not be true. A star may seem to be larger than other stars because it is so much nearer the earth.

Astronomers have put the stars into classes according to their brightness. They use the word *magnitude* for the different classes. The ancient people used this word too. The brightest stars are in the first-magnitude class. Those a little less bright are in the second-magnitude class, and so on. The stars that may just be seen with the naked eye are in the sixth-magnitude class. A telescope must be used to see stars that are fainter than those of the sixth-magnitude class.

2. Constellations of Stars

Many, many years ago the ancient people began to wonder about the stars. Night after night they looked at the heavens and wondered and wondered about them. They imagined the stars to be in groups. Then they imagined they saw the outlines of the figures of their favorite gods and goddesses and heroes in these groups. It was easier for them to remember the stars in this way; so they divided the night sky into groups of stars, or constellations. They gave the constellations the names of the gods and goddesses and heroes.

Ursa Major, or the Great Bear. Find the Big Dipper in this constellation

Some of the stars in a constellation may be millions of millions of miles apart. They are not even close enough to be in the same system or family. They just look close together when we look at them from the earth.

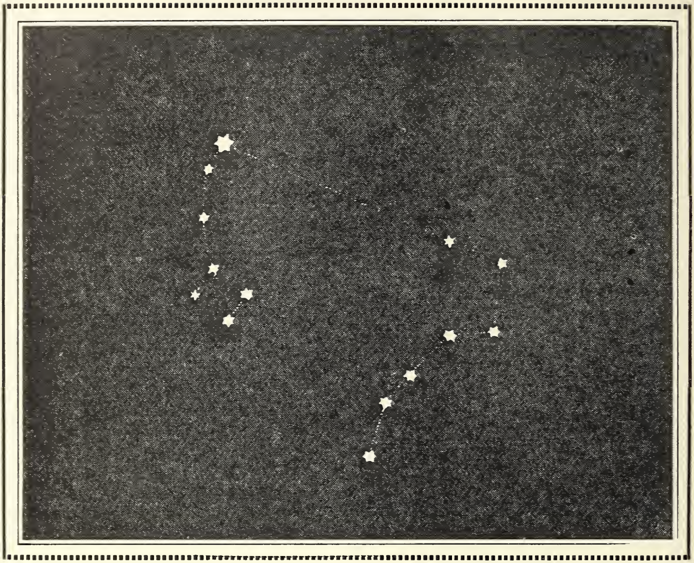
Most people know these three constellations: Ursa Major, or the Great Bear; Ursa Minor, or the Little Bear; and Orion, the hunter. Do you know them? You may know where to look in the sky to find the Big Dipper. The seven stars that make it are in the Ursa Major, or Great Bear, constellation. The handle of the Dipper is the bear's tail.

Ursa Minor, or the Little Bear. Find the North Star in the handle of the Little Dipper

After one finds the Big Dipper it is very easy to find the Little Dipper. It is in the Little Bear constellation. The end star in the handle of the Little Dipper is a very important star. It is the North Star, or polestar. This star is almost exactly over the north pole of the earth. Where we live the North Star never sets.

If you would like to find these stars some night, look for them in the northern part of the heavens. The diagram on page 150 may help you to find them.

Many boys and girls have found the constellation of Orion, the hunter. It is one of the most



American Museum of Natural History

Diagram of the Big Dipper and the Little Dipper. Two stars in the bowl of the Big Dipper point to the North Star

beautiful constellations in the heavens. The three stars in a row in the middle of the group make Orion's belt. The stars in a curved line below the belt make his sword. One can easily find this group of brilliant stars if one looks in the southern part of the sky during the winter months. Look for them in January, February, and March. During these months you ought to be able to find them.

The early people told many stories, or myths, about the different constellations. The people of

Orion, the hunter. Find Orion's belt and sword

today do not believe these myths, but they continue to call the stars and constellations by the names that were given to them years and years ago.

Things to Do

1. Find the Big Dipper.

2. Using the two stars in the bowl of the Dipper as pointers, find the North Star.

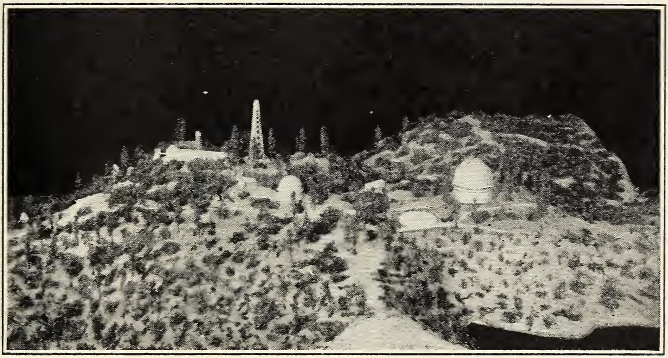
3. Find Orion's belt and sword.

4. Notice the two very bright stars in the Orion constellation. The one above Orion's belt is Betelgeuse. The one below the belt is Rigel. A very bright star near this constellation is Sirius. It is the Dog Star that follows Orion, the hunter.

Problem 2 · The Sun, our Nearest Star

1. The Sun

The sun is one of the very hot stars. There are other stars that are many, many times larger



Mount Wilson Observatory. Find out where this observatory is located. Why do we have observatories like this one?

than the sun, but they look small to us because they are so far away. Large things always appear small when they are a great distance off. Did you ever look at an airplane that was flying very high? How small it seemed! If you saw it after it had come down on the landing field, you were surprised to find it so big. Some of the large ocean ships look like small boats when seen far out at sea. So the sun looks larger to us than other stars.

The sun is one star that you do not see at night. Even if you look very closely and try to find it with a telescope, you can't see it. You can see it only in the daytime. And you can see it only on clear days, too. It is really the star that is most important to us, for it gives us our light and our heat. It gives us our food too. It gives plants the energy that they must have in order to make their food and grow. And the plants are food for us.

The sun doesn't look the least bit like the stars we see at night. For centuries people didn't know that it was a star. It doesn't look at all like the other stars because it is so very much nearer us.

Have you ever been in a place where the mercury climbed to 90° F. or over during the summer? Do you remember how warm you were? Then think how hot the temperature of the sun must be. Scientists tell us that the temperature on the surface of the sun is 11,000° F. We can't realize what such great heat would be like. The thermometers we have in our rooms wouldn't show such temperature.

The reason for this very high temperature is that the sun is a great ball of hot gases. No one could go anywhere near such a hot mass. It is rather dangerous even to try to look at this shining, bright sun. One may injure one's eyes by doing so. We know there can be no living thing on such a

This diagram may give you an idea of the size of the sun as compared with the earth and moon. The moon is shown going around the earth in its orbit. Notice the sun spot

hot body. But without the sun's light and heat there would be no living thing on our earth.

The sun is really only a medium-sized star. It appears larger than other stars because it is only 93,000,000 miles away. Does it seem queer to you to say *only* 93,000,000 miles? Our next nearest star is many hundreds of thousands of times as far away from us as the sun is; so you see why we say *only*. Think of this: an automobile going steadily, day and night, at the rate of sixty miles an hour, wouldn't reach the sun until a hundred and seventy-five years had passed.

The sun weighs over three hundred thousand times as much as the earth, and it occupies over a million times as much space. The diameter of the sun, or the distance through it, is 864,000 miles. This is one hundred and nine times the earth's diameter. Very likely you have never used such large numbers. They are so great that it is difficult even to think of them and to try to understand what they mean.

It may be easier for you to get an idea of the size of the sun and the earth in this way. Think of the sun as a large football. Then think of placing a very small-sized pea on it. The pea represents the earth. Again, if we could put the earth in the middle of the sun, the moon would be able to move around the earth 240,000 miles away, and even then the moon wouldn't be more than halfway to the surface of the sun.

2. How Fast Light Travels

Scientists have measured the distance from the earth to the sun. They have measured the distance between the earth and other stars too. They use different measures for these distances from the measures that we use for distances on the earth. They use "light years." A light year is the distance a ray of light travels in one year.

You know how short a time a second is. Light travels 186,000 miles in a second. Light waves travel much faster than sound. Traveling at the great speed of 186,000 miles in a second, a ray of light can go a distance equal to the distance around the earth seven times in one second. After a ray of light leaves the sun, it takes it only eight minutes and nineteen seconds to reach the earth.

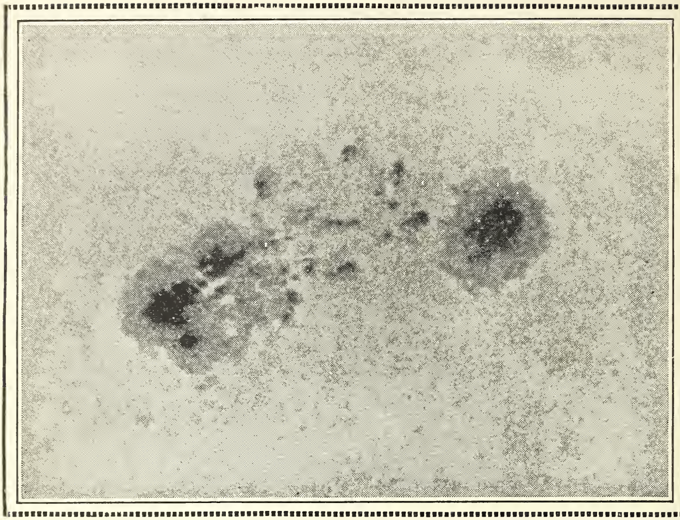
Here is a problem in arithmetic. If light travels 186,000 miles in a second, how far will it travel in one hour? How far will it travel in a day?

3. Sun Spots

Astronomers who look at the sun through their telescopes tell us that they often see dark spots on it. These dark places are called sun spots.

Sometimes sun spots look very dark, almost black, in color. They have very irregular edges. They differ greatly in size. Some of them are only 500 miles in diameter. Some of them are 50,000 miles. That means that some of them may be about six times the earth's diameter of 8000 miles.

Scientists are not sure what it is that causes these spots. They believe that they are like whirling masses of hot gases. These gases are thrown or whirled up from some part of the inside of the sun. When they reach the surface they become cooler. This cooling makes them look dark as compared



Mount Wilson Observatory

Sun spots. The story tells how scientists think sun spots are made

with the rest of the sun and so makes them look like spots. Some sun spots last only a day. There are times when there are no spots visible on the sun, but there are other times when sun spots are plentiful.

Sun spots have helped scientists to find out how fast the sun was rotating on its axis. They found that a spot near the middle of the sun turned all the way round once in twenty-five days, while a spot which was near the sun's poles turned round once in thirty days. It would seem that not all places on the sun rotate at the same rate of speed.

On the earth it is different. Here places rotate in one day of twenty-four hours.

Sun spots have a certain influence upon the earth. There are times when their magnetic power causes great disturbances. As you have already learned, they may cause northern lights. When sun spots are plentiful the magnetic needle of the compass is irregular. When the sun seems free from spots the needle is quite regular.

4. Some Stars that are Larger than the Sun

Betelgeuse is a giant star. You may think that the sun's diameter is very great, but think of this giant among the stars. It has a diameter of 250,000,000 miles, about three hundred times greater than that of the sun. It is not one of the hottest stars. Its temperature is only 4800° F., while the sun's temperature is over 11,000° F.

Betelgeuse is one of the brilliant stars in the sky. It shines with a red light. Sometimes it seems very red indeed. It may be found in the constellation of Orion, the hunter. It is the star above the three stars in the hunter's belt.

Below Orion's belt, and almost directly opposite Betelgeuse, is Rigel, another brilliant star that shines with a white light. Rigel is so far away that it takes a ray of its light over five hundred years

to reach us. And there are many stars a much greater distance away than Rigel.

Sirius is the most brilliant star of all. It shines with a white light and is often called the Dog Star. It is one of the sun's near neighbors among the stars and is about eight and one-half light years away. It is said that if the sun and Sirius were to exchange places, our earth would receive so much light and heat from Sirius that life would no longer be possible.

Look for these brilliant stars during the winter months. The picture of Orion given on page 151 may help you to find them.

Things to Think About

1. Why is the sun the star that is most important to us?

2. What are sun spots?

3. In what way do sun spots influence the earth?

4. How does the temperature of our sun compare with the temperature of Betelgeuse?

5. What is meant by *light year*?

6. For what purpose are light years used?

7. How long does it take a ray of light from the sun to reach the earth?

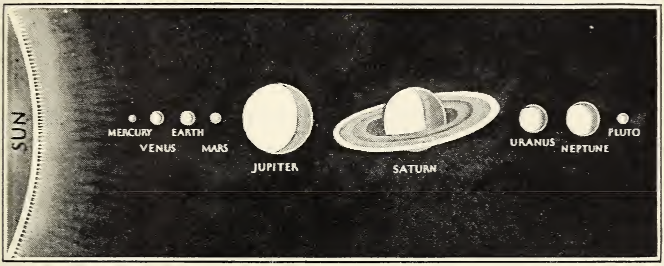
8. How may you find the North Star?

9. Why is the North Star one of the best-known stars?

Problem 3 · The Solar System

1. The Planets

Some scientists think that millions and millions and then more millions of years ago something



The diagram shows the sun and the planets that revolve around it. The story tells about other things that revolve around the sun

happened to the sun. Another star that was wandering around in space came near enough to it to pull very, very hard upon it. It pulled so hard that it raised up a huge, mountainlike piece of the sun's surface. Then it kept on pulling until this big piece was torn away from the sun and broken into smaller pieces. These smaller pieces began to move around the sun, from which they had been torn. And they have been moving around it ever since. These pieces are now called planets. The sun and the planets that move, or revolve, around it make the solar system, or the sun's family.

Although the planets are pieces that were torn from the sun, they are not like it. They have no light and no heat. They shine in the sky, but they shine by the light which they reflect from the sun. When we see them at night they look round and steady. They do not seem to sparkle as the stars do. Because they are so much closer to us than the stars, they seem to wander in and out among them. Since the planets are a part of the sun's family, they are not even near the other stars. They only seem to be near them.

Long ago the early people noticed that the planets didn't stay in the same place; so they gave them the name of wanderers, or planets. They imagined that other stars were fixed in space and did not move at all. Stars do move, but they are so far away that it is difficult to tell whether they are moving or not.

Nine planets have been discovered. They are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. Pluto has been discovered within a very few years. Some astronomers think there may be more planets beyond Pluto. Besides these nine planets, there are a large number of small bodies called asteroids, and these are planets too.

Most of the planets have smaller bodies that go around them while they themselves are revolving

around the sun. These small bodies are moons, or satellites. Our earth has one moon. Some of the planets have more moons than the earth. Some of them have no moons. Saturn has nine.

Each planet moves smoothly in its path, or orbit. There is no jarring, no jolting, no getting into the way of another planet. Why do the planets move? Long, long ago, so long ago that we don't even try to think how long ago it was, something happened to put the planets in motion. Once they were moving, no force was needed to keep them moving. Machines will stop running unless some force keeps driving them, but that isn't true in the solar system. There is nothing trying to stop the planets; so they swing along with the sun year after year.

Why are the sun and its planets always able to stay in their own orbits? The sun is in the center, or middle, of its family. It is many, many times larger than the largest planet in the group. Because the sun is so large and so near, it has great power to attract its family. Each member must remain and move in its own orbit because the sun keeps it there. This powerful attraction which the sun has for its family is called gravitation.

Are your brothers and sisters like you in every way? Members of a family usually differ in many ways. This is true of the sun's family too. The

planets are quite different from one another. Some are large, while others are small. Some have moons following them about, while others have no moons. Some stay near the sun, while others are so far away that the sun would look like a large star from them. The next stories will tell you about the ways in which planets differ from one another.

2. The Smaller Planets

Mercury

If we could start at the sun and travel away from it, Mercury would be the first planet we should come to. It is the one nearest the sun. If there is a planet closer to the sun than Mercury, we cannot see it because the sun shines so much brighter that it would hide the planet.

Mercury is so near the sun that we can see it only after sunset or just before sunrise. We cannot see it often. When we do see it we say that it is the "evening star" or the "morning star." Of course it is not a star.

Mercury is the smallest known planet. Its diameter is only 3000 miles. It is only a little larger than our moon. It is much smaller than the earth. Do you remember how large the diameter of the earth is? How many times larger is the earth's diameter than Mercury's?

Other planets do not have the same length of

year that we do. A year on any planet is the length of time it takes that planet to go around the sun. A day and night on any planet is the number of hours it takes that planet to turn all the way around on its axis. A year on the earth is three hundred and sixty-five and a quarter days. A day and night on the earth is twenty-four hours long.

Mercury has a very short year. It has the shortest year of all the planets. It is so near the sun that it doesn't have such a long path, or orbit, around it, and it goes over its orbit in a very short time. It takes only eighty-eight of our days for Mercury to go all the way around the sun. A year on Mercury therefore equals eighty-eight of our days. If we lived on Mercury we should have a birthday every eighty-eight days. Think of having four birthdays in one of our years!

Astronomers think that Mercury turns on its axis only once every year. If this be true the day on Mercury would be as long as the year. One side of the planet would always face the sun. It would always be day on that side. Think how hot it would be! The other side of Mercury would be turned away from the sun. It would always be night there, and it would be very, very cold.

Mercury is so near the sun that it gets more heat and light from it than any other planet. Do

you think you should like to live on a body that received so much light and heat? We have no reason to believe that there is any life on Mercury. Scientists think there is no air or water there; so nothing could live on it.

Venus

Leaving Mercury, we shall make our next stop on our trip away from the sun at Venus. Venus is almost twice as far away from the sun as Mercury is. I think we shall enjoy stopping at Venus much more than at Mercury.

Venus is a very beautiful planet. It is much larger than Mercury. It is only a little smaller than our earth. Sometimes it has been called the earth's sister planet. Some scientists think it is much like the earth in climate, as well as in size. It is the planet that is nearest the earth, too. It is near enough for people to make a careful study of it, if it were not surrounded by such dense, thick clouds. Scientists have not been able to see through these clouds. Some day the clouds may become thinner or disappear. Then we shall be able to find out more about Venus.

If we lived on Venus we should have no sunny days. We should probably live and die and know nothing about the beautiful night sky, about the stars, the earth, and the other planets. We should

Lowell Observatory

Some of the various shapes that Venus has when seen through a telescope. Does the picture look like anything that you have seen?

have no need for astronomers because they would be unable to see beyond the dense, thick clouds.

We know little about Venus, although it is our neighbor. We cannot tell whether it has oceans and land or whether it has any life. Scientists have had great difficulty in finding out how long the days and nights are.

If we look at Venus through a telescope, it seems to have various shapes, as the moon does. It does not always look round. It is the planet

best known as the "evening star" or as the "morning star." When it can be seen, it is one of the brightest bodies in the sky at night.

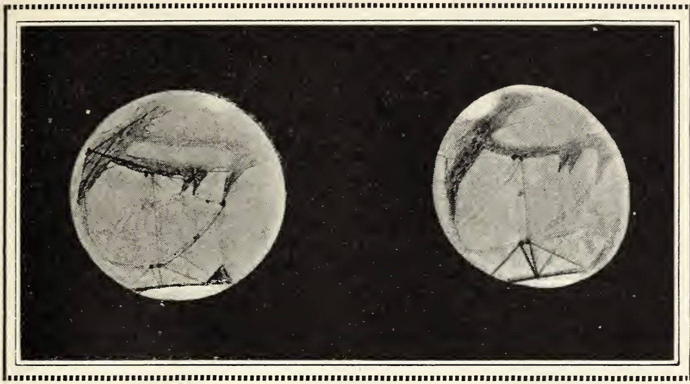
Mars

The next planet away from the sun is Earth. But we live on the earth and know many things about it; so we shall continue our journey on to Mars.

Mars is much smaller than our earth. Its diameter is only half the diameter of the earth. It is about four times as far away from the sun as Mercury is. When we see Mars in the sky at night its color is red.

Some scientists think there may be life on Mars. Some think there is no life on it. Some say that Mars has everything that is necessary for life. But we do not know whether or not people could live on the planet.

Mars seems to have very few clouds. Dark and light streaks can be plainly seen on its surface. Some people say that these streaks are canals which have been built by men. Others say that they are plants. Mars is thought to have four seasons, like the earth, although, very likely, it is no warmer at noon on the equator of Mars than it is in St. Louis or Kansas City in October or November. There are places around the poles on



Drawing by Lowell

How Mars looks through a telescope

the planet that are white. These are thought to be snow-capped. In summer these white places seem to grow smaller, as if they were melting.

Scientists agree upon a number of things about Mars. They know that it takes Mars almost twice as long to go around the sun as it takes the earth; that a year on Mars is as long as about two of our years; that a day is a little more than twenty-four hours; that Mars has two small moons and that each moon is less than twenty miles in diameter.

3. Asteroids

The asteroids are a group of small bodies that travel around the sun too; so they are members of the solar system. There are about fifteen hundred of them. Most of them are less than sixty

miles in diameter. You could walk around most of these little bodies in a short time. Their orbits are between Mars and Jupiter. They act like the large planets, and astronomers call them planets too. The greatest difference between them and the other planets is their size, for they are many times smaller than the other planets.

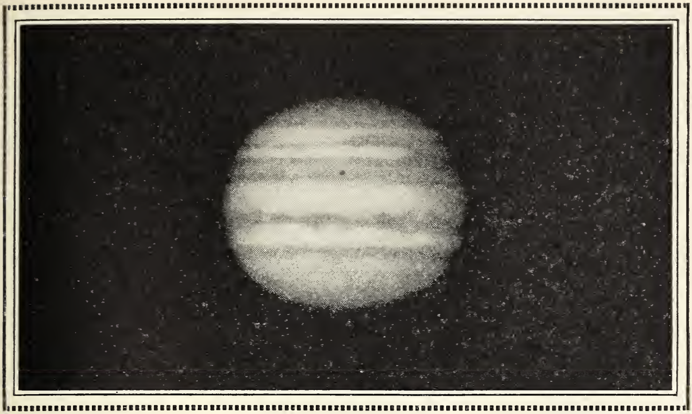
Some of the asteroids would be only large enough for a large farm; in fact, they might be too small for a ranch. But on our journey through the solar system we should not care to stop and farm them. They would be solid rock with no soil; so we could not expect to raise anything on an asteroid farm. Then, too, there would be no air to breathe.

4. The Larger Planets

Jupiter

Next comes Jupiter, the great giant of the solar system. It was probably made from the center of the huge piece that was torn away from the sun. Jupiter weighs more than any of the other planets. It weighs about three hundred and seventeen times as much as the earth. It is about thirteen hundred times as large as the earth. The diameter of Jupiter is 86,000 miles, while the earth's diameter is only 8000 miles.

Even though Jupiter is such a giant planet, it does not always look so bright as Venus. This is



Lowell Observatory

Jupiter through the telescope. Notice the belts on the surface

because it is so much farther away from us than Venus. Sometimes in the evening you can see both Jupiter and Venus in the western sky. The large planet high in the sky is Jupiter. Venus is so near the sun that it is seldom seen high in the sky.

Jupiter has nine moons. Four of these moons are very large. The largest one is about the size of Mars. The smallest one is the size of the earth's moon. Astronomers have been observing these moons for many years.

Jupiter has beltlike spots on its surface. No one has ever found out what these spots are. Some people think they are belts of clouds. They are brown, yellow, red, and tan in color. One large

red spot has appeared and disappeared a number of times. Some people think that these spots are caused by storms.

If you lived on Jupiter you wouldn't grow old in years very fast. You would have a birthday only once in twelve of our years. If you like birthday parties you wouldn't care to live on this planet. Jupiter is five times as far away from the sun as the earth is; so it has a much longer path to travel around the sun. A day on Jupiter is very short. It is only ten hours long.

If a year on Jupiter equals twelve of our years and its day is only ten hours long, can you find out how many days there are in Jupiter's year?

Saturn

Now we stop at Saturn. Saturn is next to Jupiter in size, and it is next to Jupiter in its distance away from the sun. It is about ten times as far away from the sun as the earth is.

Saturn is usually considered the third brightest planet. It is colder than Jupiter. Its year is equal to thirty of our years. It rotates on its axis in ten hours; so its day is a little more than ten hours long.

A very interesting thing about Saturn is its rings. No other planet has rings. These rings are thin and flat. They seem to be made up of many

Mount Wilson Observatory

Saturn. This planet has interesting rings. None of the other planets have rings

very tiny pieces that reflect the light of the sun. Besides its rings, Saturn has nine moons. Eight of these moons move around the planet in the same direction. One of the moons moves around the planet in the opposite direction.

Uranus

The first six planets that you find as you go away from the sun were known to scientists as long as three thousand years ago. The other three planets have been discovered during the last two hundred years. Uranus, the seventh planet as we travel from the sun, was discovered in 1781.

Uranus is the fourth planet in size, but it is about nineteen times as far away from the sun as

the earth is. It cannot be seen with the naked eye. Even when seen through a telescope, it looks very small. It is not near enough to be easily studied.

We do know that it takes Uranus eighty-four of our years to make one trip around the sun. Uranus has four moons. It is a very cold planet because it is so far away from the sun.

Neptune

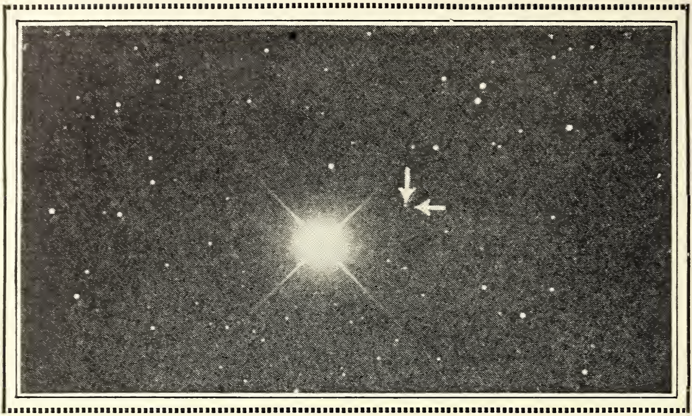
Neptune was discovered in 1846. It was discovered in this way. Scientists know that all bodies have gravitation. They also know how much one body attracts another. It was noticed that Uranus was being pulled out of its regular path around the sun. Two young men used their knowledge of mathematics to find out how much it was being attracted, or pulled. By more work in mathematics they were able to tell about where the object should be that was pulling Uranus out of its path. They told other astronomers where to look for it. Using their telescopes, the astronomers looked, and they found Neptune close to the place where the scientists had said it would be! Isn't it strange to think that scientists, with pencil, paper, and mathematics and the knowledge that other scientists have learned, can sit at a desk and tell where a planet is?

Very little is known about Neptune, except that its year is one hundred and sixty-five times our year. It is so very far away that it takes it a long time to revolve around the sun. It is so far away that it can be seen only with a telescope. It is the third largest planet in size, and it has one moon. It must be very cold on Neptune, since it is so far away from the sun.

Pluto

Pluto, the ninth planet, and Neptune were discovered in much the same way. A number of years ago Dr. Lowell, at Flagstaff, Arizona, figured out where such a planet should be found, but it took a long time to find it. Pluto was found by photographing a certain part of the sky until a moving spot was seen. This spot was in different positions in different pictures. It turned out to be Pluto.

This planet has not been known long enough for scientists to tell many things about it. They think the distance from Pluto to the sun is thirty-nine times the distance from the earth to the sun. Of course we should not be able to see Pluto without a telescope. Its year is at least two hundred and forty-eight of our years. It is so far away that if we were able to travel out to it, the sun would look only like a brilliant star. Do you think you should



Lowell Observatory

The small spot marked by two arrows in the picture is Pluto, the ninth planet. It was discovered a short time ago. The large star is δ Geminorum

like to live on Pluto? Your days wouldn't be very bright. You might not be comfortable.

Think how cold it would be on a planet so far away from the sun! Pluto has no heat except what it gets from the sun. Scientists think it would be so cold that oxygen and nitrogen would change to a solid; so we shouldn't be able to stay there even if we wanted to.

Some of our great astronomers think that there may be more planets out beyond Pluto because certain of the planets are pulled out of their regular path a little as they go about the sun. You may read about their discovery some day — that is, if they are really there.

5. Other Members of the Solar System

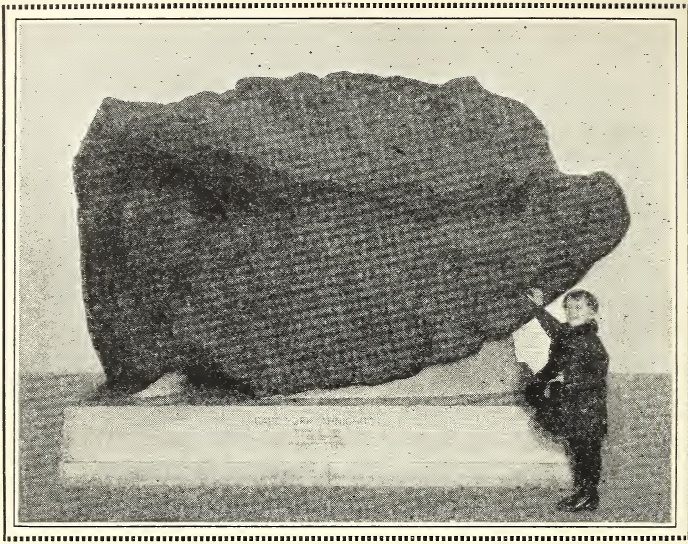
"Shooting stars"

When you were looking at the heavens on a clear, dark night, did you ever see stars suddenly shoot across the sky and disappear?

They were not really stars that you saw; they were meteors. Most people call them "shooting stars." Some nights a great many meteors can be seen. There are so many of them that they seem to be in swarms. It is said that millions and millions of them big enough to be seen with the naked eye dart into the earth's atmosphere every day. And if a telescope is used, hundreds of millions may be seen every day.

Meteors are small, solid bodies that look like rocks. Some of them are very tiny. Others are large enough to weigh several tons. Most meteors are no larger than a walnut. Some are made mostly of iron and nickel. Some are made of iron, nickel, and stone. Others are almost all stone.

Meteors belong to the sun's family. They too revolve around the sun in orbits as the planets do. It happens that their orbits often cross the earth's orbit. Then we see them. They dash toward the earth with great speed. When they reach our atmosphere their contact with the air causes them



American Museum of Natural History

A meteorite that fell on the solid part of the earth. Why do you suppose the boy is shown in the picture?

to become very, very hot. Then they give off light and appear as shooting stars in the sky.

Do you remember how people, years ago, made light by rubbing pieces of stone or flint together? The friction that was caused by the rubbing was what made the light. If you rub or scratch a match on a piece of sandpaper, the match lights. Again it is the friction that makes the match light. So it is with meteors. When they reach our atmosphere and rub against the air, the friction caused by the rubbing makes them hot, and we see them.

Usually the smaller meteors give off a flash of light and are burned to dust or vapor in an instant.

Sometimes meteors are so large that they go right through the atmosphere and fall on the solid part of the earth. Then they are called meteorites, not meteors. Many of them are kept in museums.

Scientists think that meteors may be small, scattered parts of comets' tails.

Comets

The word *comet* comes from a Greek word that means "long-haired." That seems to be a good name for these members of the sun's family, for they have a head with a tail streaming out from it. Some comets have more than one tail. The tails may be short, or they may be very, very long.

Comets remind us of a person who is coming into the presence of a king or queen. He is always very careful to keep his face toward the monarch. He backs out of the room when he is leaving. So it is with comets. They come into the presence of the sun headfirst. When leaving they back away, the tails going first. The comets' tails always stream away from the sun. This is caused by the great force of the light that comes from the sun. Sometimes these tails break up into small pieces.

Lowell Observatory

Halley's comet. A member of the sun's family that is seen every seventy-six years

Years ago it was thought that comets were only visitors; but now we know they are probably members of the sun's family all the time, although they may travel a long way from the sun.

When a comet, with its bright, flaming tail, appeared in the darkness of the night sky, the ancient people were filled with great fear. To them it meant that terrible things were about to happen.

One of the most famous comets known is Halley's. It is named for the Englishman who discovered it. It may be seen every seventy-six years, because it takes the planet that length of time to revolve around the sun. It last appeared in the year 1910. When should it appear again?

There is another comet which may be seen every three and a half years. This comet was discovered by a German named Encke.

Things to Think About

1. How does a planet differ from a star?

2. How does a meteor differ from a meteorite?

3. How many different kinds of heavenly bodies can you name?

4. If you lived on Neptune, how many of our years should you have to live before you had a birthday?

5. Why do you think the earth is a better place to live on than any other planet?

6. Why do we know more about Mars than about any of the other planets?

7. A long time ago a famous astronomer, Sir John Herschel, gave us something to think about when he suggested how we might get an idea of the size of the solar system. He suggested that we use a very large ball, about 2 feet across, to represent the sun. At a little over 80 feet away put a mustard seed for Mercury. Venus would be represented by a pea 140 feet away. Another pea, 215 feet away from the big ball, would be the earth. Mars would be something much smaller, 325 feet away. Jupiter would be a small orange nearly a quarter of a mile off from the two-foot ball, while Neptune would be a plum, at about a mile and a quarter. We might add a small pea for Pluto, which was discovered only a short time ago, and put it at a little less than two miles from the ball. What about the stars? Where should you put another large ball to represent one of them? Herschel found that you would have to put this ball eight thousand miles away, or as far as the distance through the earth.

Things to Do

1. In a good almanac find which planet is called the evening star at the present time. Look for this planet after the sun sets.

2. Sometime you may be able to visit a natural-history museum in some large city. If you do, look for meteorites or pieces of meteorites.

3. Explain why it is that, although the sun gives off so much heat and light, only a tiny fraction of this reaches the earth.

Problem 4 · The Story of the Moon

1. What is the Moon?

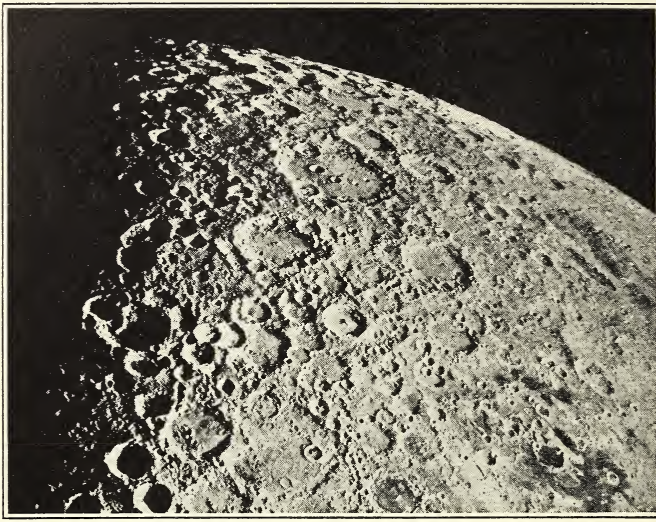
Children often ask this question. The moon seems so mysterious to them. They try to see "the man in the moon" or "the woman's head." There is no man and there is no woman's head in the moon. People just imagine that they see these things.

In the very earliest times people worshiped the objects which they saw in the sky. They worshiped them because the heavenly bodies filled them with wonder and fear. They were eager to know more about the moon. Because they observed it so much, they did learn many things about it.

Today some astronomers think that millions and millions of years ago the earth and the moon were one body. How many millions of years ago this was, they do not know.

Although the moon may have separated from the earth, it didn't go very far away. It is the nearest neighbor the earth has. It still belongs to the earth. It is the earth's satellite. Wherever the earth goes, the moon also goes.

To the people on the earth the moon looks very large. It looks as large as the sun. That is because



Mount Wilson Observatory

Mountain peaks and crater rings on the moon's surface as seen through the telescope

the moon is so much nearer the earth than the sun is. We have learned that the sun is 93,000,000 miles away from the earth. The moon is only 240,000 miles away.

Here is a problem in arithmetic for you. Can you do it?

If the sun is 93,000,000 miles away from the earth, and the moon 240,000 miles away, how much farther away is the sun than the moon?

A more difficult problem for you would be to find out how many times farther away from the

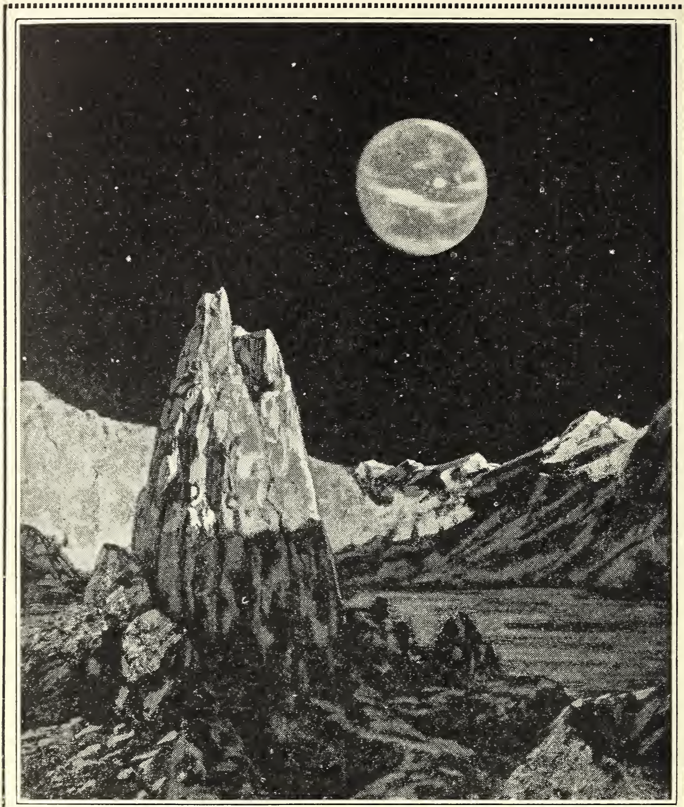
earth the sun is than the moon. Do this problem by long division.

Compared with the sun in size, the moon is very, very tiny. It is small compared with the earth also. The diameter of the moon, or the distance through it, is only 2160 miles. The distance through the earth is about four times as great. The sun's diameter is tremendous. It is over 860,000 miles.

How we should miss the moonlight nights if anything should happen to our moon! It seems strange to think that the brilliant light that comes to us from the moon comes from a body that has absolutely no light of its own. It merely reflects the light of the sun. This reflected light shone on the earth long before there were human beings living here.

Scientists tell us that the sun gives the earth more light in a half-minute than the moon gives, by reflection, in a year.

We have learned that the earth and the other planets reflect light from the sun too. You know how bright a moonlight night on the earth is. Suppose it were possible for you to live on the moon. Think how bright an earth-light night would be there! The earth, being larger than the moon, would reflect much more light. The full earth would be far more brilliant than the full moon.



©American Museum of Natural History. Painting by Howard Russell Butler

A picture of a part of the surface of the moon as an artist imagined it. The moonlike object in the sky is our earth

Do you think there is any life on the moon? Plants and animals could not possibly live on the moon. They need air and water. The moon has little or no atmosphere and no rain or water.

It has no soil. It has no forests. Plants would not be able to make their food. Without plants there could be no animals. There seems to be nothing on the moon but rock and more rock. There is only one day and one night on the moon while we are having thirty days and nights. The days must be very warm, and the nights very cold.

Astronomers have looked at and studied the moon through telescopes. They tell us that the surface seems to be solid rock. It appears to be quite rough and uneven. There are many mountain ranges, with some very high peaks. The mountain sides are steep because there is no water and therefore no erosion on the moon. There are many large holes. Some of these holes measure one hundred miles across and are over three miles deep. It is thought that these holes may be craters of old volcanoes, or they may have been formed by the falling of meteors onto the moon. The moon has no atmosphere to check the fall of meteors; so they would make big holes in its surface.

When we look closely at the face of the shining moon, we see dark places on it. Some of the rocks on the moon may be darker than others. The dark places that we see may be made by the darker-colored rocks. People often imagine these dark places are the eyes, nose, and mouth of a man's or a woman's face.

2. Changes in the Moon's Appearance

Does the moon always look the same to you when you see it in the sky?

A most unusual thing about the moon is that it does not always look the same. It seems to change its shape. Sometimes it seems to be just a thin sliver. We call this the crescent moon. Sometimes it shines full and round. At other times it seems to be just a half-moon.

We have said that the moon has no light of its own, but reflects the light received from the sun. The half of the moon that faces the sun is always light. But we on the earth cannot always see all the half of the moon that the sun illuminates, or shines upon. Sometimes most of the illuminated part of the moon is turned away from the earth. Then we see only the edge lighted. This is the thin crescent, or the new moon. This happens when the moon, in its path, is between the earth and the sun. The new moon always appears low in the western sky after the sun has set.

As the moon continues its journey around the earth, it arrives at different places in its orbit. Its position with reference to the sun and the earth then changes. It is not always in line with them, and more and more of its illuminated portion may be seen. When we see half the illuminated

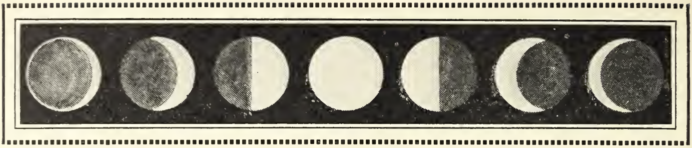
a. Only a small part of the illuminated face of the moon is seen here. We call it the new or crescent moon. *b.* The full moon, showing dark places on its face. Why are there dark places on the moon's face?

part of the moon, we call it the first quarter. It looks like a half-moon to us. It is really half of the illuminated half of the moon, or one quarter of the whole moon.

After we see the first quarter, we begin to see more and more of the illuminated face, until the full moon appears. It may be seen about two weeks after the new moon. At this time the moon is on the side of the earth away from the sun.

The moon rises about fifty minutes later each night. The full moon usually rises in the east just as the sun is setting in the west.

The moon does not remain full very long. It goes on its way around the earth, and we begin



The phases of the moon. Can you name these different phases?

to see less and less of the illuminated part. Once again a half-moon appears. Now it is the last quarter that we see. The illuminated part of the moon is waning, or growing smaller in size. It is not so brilliant as it was. Then it finally disappears, and we see no moon. But soon the crescent moon comes again in the west. These monthly changes in the appearance of the moon are called the phases of the moon.

3. Why we always see the Same Side of the Moon

The moon seems to look different because it is always moving. It has two movements. It revolves, or travels around the earth. It also turns on its axis. But it turns on its axis only once in going once around the earth. That is a strange thing about the moon. Because it turns only once on its axis in going once around the earth, we always see the same side, or face, of the moon. We have never seen its other side. It takes the moon a little less than one month to complete

both its journey around the earth and its rotation on its axis.

If you wish to experiment a little, stand in the middle of a room. Imagine that you are the earth. Hold a ball or orange in your hand. Color one half of it. Stretch your arm out to its full length, still holding the ball or orange in your hand. Rotate, or turn, your body all the way around. While you are doing this, notice that you always see the same side of the ball or orange. If there are other people in the room, they may see all sides of the ball or orange as you turn round, but you, the earth, do not.

This experiment should help you to see why the moon always turns the same face to the earth.

4. Tides

No doubt you have heard people say "The tide is coming in" or "The tide is going out."

The water of the ocean rises and falls at regular hours each day. This regular rising and falling of the water is called the tide. The rising water is called flood tide. The falling water is ebb tide.

It seems queer to think that the moon, which is so far away, has anything to do with the rising and falling of the water of the ocean; but it has a great deal to do with it.

Scientists know how the force of gravitation in our solar system acts and what it does. They know the earth weighs over eighty times as much as the moon. The force of gravity is six times as great on the earth as on the moon; so if one could jump six feet high on the earth, one should be able to jump thirty-six feet high on the moon.

The earth and the moon attract each other. The attraction which the moon has for the earth has a lot to do with causing the tides. The sun also helps to cause the tides, but the moon is so much nearer the earth than the sun is that it has much more to do with the tides. The rotation of the earth on its axis helps to make the tides move about on the earth.

As the moon wanders on in its path, it is sometimes in the line of the sun and the earth. Then the sun and the moon pull together on the earth and cause very high tides. These high tides are called spring tides. At other times the sun and moon are not in line with the earth. They do not pull together. Then the low tides are lowest. They are called neap tides.

Spring tides and neap tides occur about every two weeks. Spring tides occur when the moon is new, and again when it is full. Neap tides occur halfway between the spring tides, at the first and last quarters of the moon.

Even the ancient Greeks and Romans knew that the moon had something to do with causing the tides. They spent much time trying to find out how the moon caused the water to rise and fall.

5. Why it is Important to know about Tides

One of the most important things for men who command and sail ships to know about is the tides in the ocean. There are seaports and harbors in the world that vessels can enter only at high tide. Their channels are unsafe at other times because they are too shallow. Many ships are wrecked by running on the sand bars and the rocks in these harbors.

There are carefully made tables which tell us when the tides are high and when they are low. These tables may be obtained in all the big seaports of the world.

You have perhaps seen the time of high tide posted at some sea-bathing place which you have visited.

Why should the time of high tide be posted at the beaches?

Tides help to keep the harbors free from floating rubbish. They help to keep the channels open. They carry much waste material out to sea.

Things to Think About

1. Does it seem strange to you to think that the moon helps the commerce or trade of the world? How does it do this?

2. Why do we always see the same face of the moon?

3. Why does the moon shine?

4. Why doesn't the moon always look the same?

5. Why is there no life on the moon?

6. Why are there no clouds on the moon?

Things to Do

1. Write a story about the side of the moon that no one sees.

2. Describe a journey to the moon.

UNIT VIII

Around Us

1. Light
2. Heat
3. Water

AROUND US

Almost everyone is interested in knowing whether there are other worlds like ours. Is Mars or Venus inhabited by beings like ourselves? Do the other stars have planets? Such questions cannot always be answered, but we do know something about the needs of living things on the earth. They need air, water, warmth, and food. In this book we are studying all these things that are necessary for life.

As we look around in the universe we do not find any worlds which have just the right amount of these things. We need an atmosphere, or air about us, but we cannot live on air alone; for we want something solid in order that our crops and forests may grow and that we may have a place to build our homes, sidewalks, and streets. We need water, but we do not want too much, for it might ruin our crops and drown us. We want warmth, but we do not want it too hot. Perhaps we are hard to please. We can have too little or too much of some of these things that we must have in order to live. You have already studied about air. Read this next unit, and you will learn about light, heat, and water. Later you will read about how living things get their food.

Problem 1 · Light

1. What is Light?

Did you ever stop to think what a wonderful thing light is? Light is so near us and so easy to have that we forget how important it is. Yet we do most of our work during the daytime. We go to school, father goes to his office or factory or farm, mother goes to shop, during the day.

Many flowers open their petals, and many animals are busy hunting food, while it is light. Let us see just what light is and why it is so important.

Of course, when we first think of light we think of sunlight, for that is really where we get light after all. This great body, the sun, gives us almost all our light. When you stop to think that the light we enjoy was made 93,000,000 miles away and travels at a speed so great that in eight minutes it reaches us, you will begin to realize how wonderful light is.

For centuries some of the most intelligent scientists have been working upon the puzzling study of light. They have wondered what means the sun uses to speed the rays of light to the earth. Even wind does not bring light, because wind is moving air, and air extends only a few hundred miles out into space.

Scientists have wondered what there is between the end of the atmosphere and the stars, the planets, and the sun. Many of them think there is nothing out beyond the atmosphere. They sometimes call it a vacuum, because there seems to be nothing there. Yet light travels right through this great vacuum.

When Edison invented electric lights he removed the air from the bulb and made a vacuum around the wires. The light from the wires inside the bulb had to shine through this vacuum.

It has been said that the universe, with its stars and planets, may be as empty as a large building would be if it contained but two bits of dust.

You must not think that scientists have found out all there is to learn about light. They are still experimenting and discovering new wonders concerning it. While you are living they will probably discover many new things which are not yet dreamed of in regard to light. They may also show that some of the things which we now believe to be true concerning light are not true.

2. Why Light is Important

Light has been called the mainspring of life. Just as a watch runs by a tiny mainspring, so our lives are run by light. It is the energy, or power,

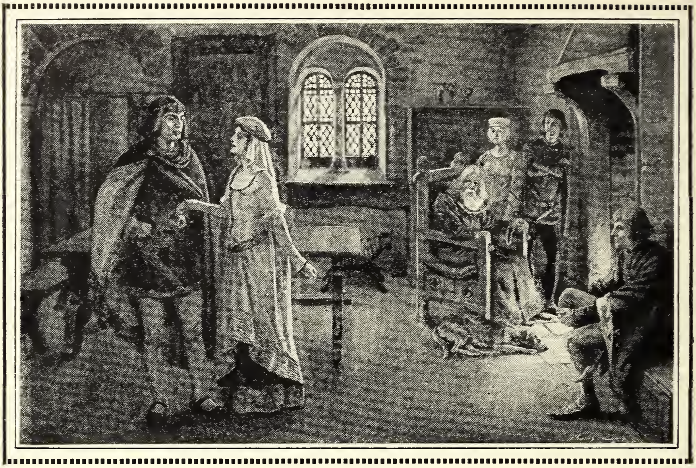
which plants use in making food. We get our energy from the sun by eating plants or by eating animals which have eaten plants. Without light everything would soon die, and this earth would be only soil and rocks. There would be no living thing upon it.

Light destroys certain bacteria and germs which cause diseases. Long ago people did not value light as we do today. Their houses were dark. They had no glass windows. These people often had a disease which we now know how to escape. We need plenty of sunlight on our bodies in order to escape this disease.

The sunlight which comes into our houses through glass windows is not enough, unless the windows are quartz glass. Ordinary glass does not let through the short rays of the sun, which are so valuable to our bodies. The best way to be sure of enough sunlight is to stay out in it as much as you can each day.

Sun baths are becoming very popular. Bathing suits and sun suits allow the sun to reach much of your bodies.

Many persons take sun baths because they know that sunlight is very important if they wish to have strong, healthy bodies. When taking sun baths, one should be careful not to remain in the strong sunlight too long.



The interior of a room in a palace of long ago.
Why would this room receive very little sunlight?

Children, and grown people too, often abuse their eyes by trying to read or write in a poor light. A light that is too bright or too dim may cause eyestrain. Children sometimes strain their eyes by studying or reading for too long at one time. When one is reading, writing, or studying it is a good plan to look away from the printed page now and then. This relaxes the muscles of the eyes and rests them.

When you are writing, try to sit so that the light comes from the left. If you do this, no shadows will be made on your work by your right hand.

The interior of a room in a home of today. In which of these rooms should you prefer to live?

A great many harmful germs and bacteria get into the air about us. Few of these harmful bacteria can continue to live in strong sunlight; so by killing these germs the sunlight helps us to keep well.

3. What is Darkness?

Where there is no light, there is darkness. When the sun's rays no longer shine on your half of the earth, that half is dark.

If an object gets in the way of light it throws a shadow; that is, it does not let light shine directly upon the spot below or beyond.

Objects which make light do not cast a shadow.

The cool shade which you enjoy on hot, sunny days is possible because the leaves of the trees are between you and the sun. They cast a shadow which you call shade. Posts, houses, poles, all cast shadows. These shadows seem to move about during the day. Can you explain why this is true?

A long time ago men were afraid of darkness. They thought that evil spirits stole the sun away and ruled the night. They were glad to see the sun return each morning. Now we need not be afraid of darkness, for we know that day and night are caused by the earth's rotating on its axis.

4. What we See

Light helps us to see two kinds of objects. Flames, electric lights, the sun, and stars are objects which we see because they *give off light*. We see chairs, desks, houses, people, and many other things which do not give off light. We cannot see them in a dark room because they make no light *of their own*. We can see them by reflected light. Many objects reflect the light from the sun or from artificial lights. As light strikes these objects, it is reflected off from them. Some of this reflected light reaches your eye.

Light is being reflected from objects about us all the time. The sun does not always shine di-

rectly into our homes; yet we see inside them because of the sunlight. The objects outdoors reflect the light from the sun. Some of this comes in through the window. Even the tiny dust particles which you cannot see reflect the light from the sun.

5. Why we have Light on a Cloudy Day

Sometimes clouds get between us and the sun. Then we say that the sun is not shining, but such a statement is not true. The sun is always shining. It never stops shining. The only reason it is not shining on us is that clouds have come between the sun and us. These clouds throw shadows on us.

You might wonder why any light comes through the clouds. Even on the cloudiest days there is usually a good deal of light. The light we get on cloudy days is reflected light. The raindrops in the clouds reflect light from one drop to another, back and forth, and some of the light gets to the earth. When very thick clouds form, less of the light is reflected to the earth. That is why we sometimes have to turn on artificial lights even in the daytime. Light that is reflected from objects that have no light of their own is usually softer than the direct light that comes from the sun.

6. What is the Sky?

The sky looks like a great bowl turned over the earth, but of course it isn't. If you should travel upward in an airplane, you would not reach any one place called the sky. It would still be above you, no matter how high you flew.

The sky is really caused by the scattering of the rays of the sun by the tiny particles in the air. These tiny particles give the effect of the domelike sky.

7. Why you can see through Some Things and not through Others

In ancient days kings of countries spent much money building beautiful palaces in which to live. I doubt that even with all their richness and splendor you would choose to live in many of these palaces. They were dark and gloomy places. Very little light was admitted into these palaces. This was before the days when glass was manufactured in quantities.

Glass is a great invention. It lets light pass through it. We say that glass is transparent. All transparent objects let light pass through them.

Most objects are not transparent. All objects which do not let light pass through them are called opaque. Wood, iron, and oilcloth are opaque.

8. Colors

Without light there would be no color at all. The world would be all black, and black is no color. It is only the absence of light.

Sunlight is usually spoken of as white light. Sometimes this white light gets broken up, or separated. We then see the rainbow colors.

People have been very superstitious about the rainbow. A rainbow sometimes follows a thunderstorm. Some of the ancients thought the thunder was due to giants or gods throwing hammers about in the sky. After the rain had stopped and the thunder had ceased, they thought the giants had gone back to their homes by crossing this beautiful bridge.

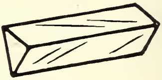
We can see a rainbow sometimes in the spray when we water the garden or lawn. Sometimes we can see it in waterfalls. The tiny drops of water in the air break up the white sunlight into its six colors — red, orange, yellow, green, blue, and violet. You can do the same by holding a glass prism in the sunlight.

The color of an object is due to the color that is reflected. A blue sweater absorbs all the colors except blue and reflects blue. A pair of red slippers reflects red. The flag is red, white, and blue because of the colors it reflects. When an object

reflects almost all the colors, it is white. Chalk, paper, and snow reflect almost all the colors.

In painting with water colors, you know that you use many colors besides those found in the rainbow. You can secure different shades and colors, such as pink, purple, lavender, brown, and so on, by mixing the different colors in different amounts. It may be fun to experiment with mixing colors. Some children like to mix their own colors when they are painting pictures. They get unusual color effects by doing so. You might make recipes for mixing certain shades of color.

Things to Think About



1. Explain why you can see yourself in a mirror.

2. Name all the things you can think of which give off light.

3. Name some things which are seen only by reflected light.

4. What do you think would happen if light could not be reflected?

5. Why should you spend as much time as possible out of doors?

6. Why is the sky dark on a cloudy day?

7. Name the six colors that may be seen by breaking up the sunlight.

Do You Know

1. Why one should spend some time in the sunshine?

2. By looking at a potted plant that grew indoors, from which direction the light came?

3. Why we should walk on the sunny side of the street and play in the sun, except in the hottest weather?

4. Why we should wear light clothing in summer time?

5. That sunlight has power to kill germs?

6. That sunlight helps to prevent and cure certain diseases?

7. That it is thought that sunlight is necessary in order that our bodies may grow and develop as they should?

Problem 2 · Heat

1. Temperature is Important to Life on the Earth

You have certainly read about Commander Byrd's trip to the south pole. You probably recall the many preparations the men made for the long winter months they had to face. Do you remember that many of these winter days were so cold that the thermometers registered 60° F. below zero? Is that cold? Should you like to take a long hike on such a day?

Now let us think of the kind of weather we should have if we went on an expedition into the jungles of the tropics. Instead of being terribly uncomfortable because of the cold, we should be uncomfortable because of the extreme heat. Here our thermometer would register around 120° F. day after day.

There is a big difference between the temperature at the poles and at the equator of the earth. However, the temperature at the poles is not the coldest temperature in the universe. If you could dress warmly enough and if an airplane could go out into space beyond the atmosphere, you would then find out what cold really is. A special thermometer would have to be made to record the

temperature, for it would register far below zero — yes, over 400° F. below zero.

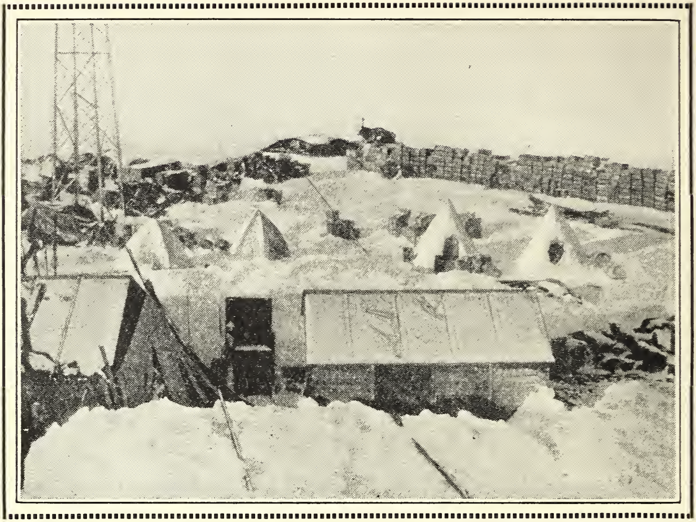
If your airplane could keep on traveling for 93,000,000 miles, you would reach the sun. There you wouldn't have to worry about ever getting too cold. You would worry about ever getting cool again. As a matter of fact, you couldn't endure this extreme heat of about 11,000° F.

Some of the planets have more extreme temperatures than our earth does. Some have colder nights and hotter days than we have here on earth. For this reason they may not make good homes for plants and animals. Plants cannot grow upon them because the weather is not right for their growth. Since plant life is essential for food for people, man cannot live where plants cannot grow.

It is fortunate for us that the earth gets warm enough, but not too warm, for plants to grow. If it were too warm, plants could not grow and would die. If it were too cold, plants would become inactive and would not blossom, make food, and go to seed.

Plants do not grow when the thermometer registers as low as 32° F. That is the temperature at which water freezes. Since plants cannot use ice for making food, they cannot grow at that temperature.

Water boils at 212° F. This temperature is



© Byrd Antarctic Expedition

Snow scene in Antarctica. Should you like to live here?

much too hot for plants. They wither and die long before the thermometer registers 212° F. Most plants cannot grow when the temperature goes beyond 122° F.

The temperature of the earth depends upon many things. If the earth should get too close to the sun, it would become too hot for plants and animals to live upon. If it should wander off into space, it might become so cold that plants and animals would die. If the earth should lose its blanket of air, the temperature during the day would be much hotter, and during the night much

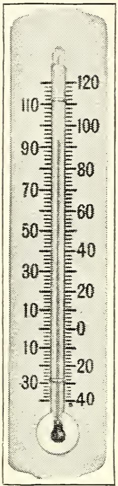
Natives in a tropical jungle. These natives need very little clothing. Why?

colder, than it is now. If all the water of the earth were to disappear, how would it affect the temperature? If the earth rotated more slowly, so that our days and nights were longer, how would it affect the temperature of the earth?

2. What Temperature is Just Right for Man?

It might be well to find out just what temperature is most healthful to live in. Scientists have found that the ideal temperature is 68° F. It has been found that people do not have so

many colds in winter if they do not overheat their homes. If the thermometer goes to 72° F. or 75° F., we become uncomfortably warm. If the thermometer goes to 60° F., we feel cold.



A thermometer. Do you know how to read a thermometer? The story tells why the mercury moves up and down

Much of our comfort depends upon the humidity of the air, or the amount of water vapor in the air. On many days in the summer there is so much water vapor in the air that perspiration on our skin cannot evaporate. When this happens, our bodies cannot get rid of their heat. At such times we are likely to think that the temperature is much higher than it really is.

We cannot depend entirely upon our feelings to tell us the temperature. Just after an hour of fast skating we should feel warm even if the temperature in our houses were around 60° F. Likewise we should feel cold upon coming into a house the temperature of which was at 68° F. if we had been standing on a cold, windy corner waiting for someone.

It is because we cannot depend upon our feelings to tell us the temperature that we need thermometers. Let us see how one works. Examine

the contents of the glass tube and bulb. You will see either a heavy silvery liquid, called mercury (or quicksilver), or a colored liquid, which is really alcohol and colored so that you can see it easily.

The mercury or alcohol moves up and down in the tube according to the temperature. On very warm days the mercury will be farther up in the tube than on cold days. Here is the reason for it. Almost everything expands when heated. Mercury and alcohol do, too. As they expand they rise in the tube. Things contract as they become cool. That is why mercury and alcohol descend in the tube as the weather grows cold.

All you need to do, in order to find out how hot or how cold it is, is to look at the mercury in the tube of the thermometer. The figure which is opposite the top of the mercury tells you the temperature at that time of day at that place.

3. What is meant by Freezing?

We have been talking a good deal about water's freezing at 32° F. Just what do we mean when we say that a thing freezes? Whenever a liquid changes to a solid because of cold we say that it freezes.

We usually see iron, glass, paraffin, tallow, and

butter in their solid state. Some but not all of these things change to solids at a high temperature. They do not wait until the mercury drops to 32° to freeze, as water does. They become solids when the temperature is much higher than that.

You might like to discover at just what temperature some of these things really do change to solids. Heat a bit of butter in a pan. Set it away from the fire. Just as it starts to harden put a thermometer into it and read the thermometer.

Do the same with tallow, lard, or paraffin. Do not try to find out when iron changes to a solid. If you want to watch iron harden, go to an iron foundry. There you will see huge vats of melted iron being poured into molds to harden. The men handling the hot liquid will look very hot. They will be careful not to have an accident with the iron. A burn from liquid iron would be much worse than from hot water because the temperature of liquid iron is much hotter than that of hot water.

Mercury freezes also, but it freezes at a very low temperature. When the temperature goes to 39° F. below zero, mercury freezes. Alcohol freezes at a very low temperature. Why is it placed in the radiators of automobiles in freezing weather?

Joan is carefully closing the envelope with sealing wax before mailing her letter

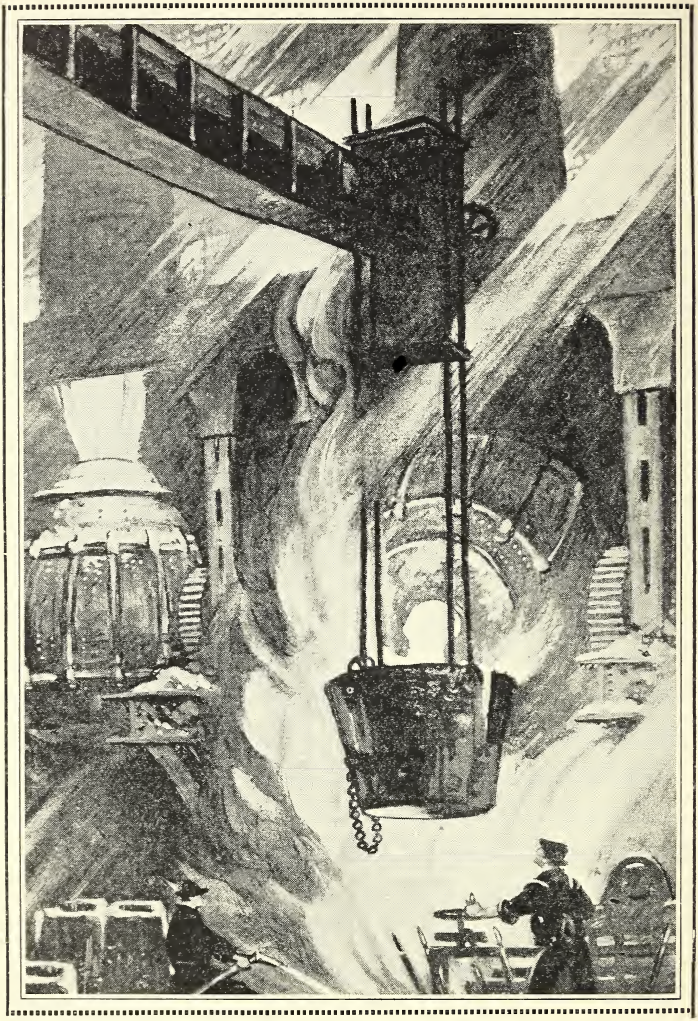
4. What is Meant by Melting?

We say that things melt when they change from solids into liquids. Water melts at 32° F.

Butter, paraffin, lard, tallow, all melt when they are heated. They have a low melting point; that is, they need only a little heat to change them from solids to liquids.

Other substances have a high melting point. Lead, tin, iron, all are hard to melt. Much heat is needed to change them from solids to liquids.

Sometime you may wish to send a letter or package which is sealed with sealing wax. Heat-



Melted iron being poured into molds to cool. The two huge barrel-shaped things are called converters. Find them in the picture

ing the wax a little makes it melt. It cools rapidly, and becomes a solid as it cools.

The melting and freezing points of a substance are the same. For instance, the melting point and freezing point of water are both 32° F.

Watch the melted wax of a candle as it drips down the side of the stick. Does it stay a liquid long? Do you think it changes to a solid at a high or a low temperature?

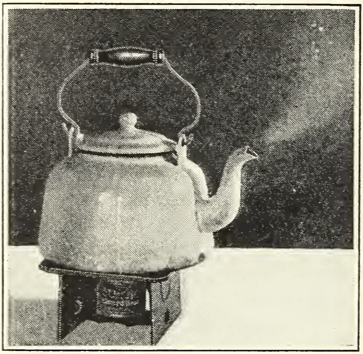
What do you think would happen if everything melted at 32° F., as water does? Think of the many things which are now solid that would then be liquids! Steel skyscrapers and bridges would melt and run away. Big machines in factories would spill all over the floors. Can you see why it is fortunate for us that some solids melt at a very high temperature and some at a low temperature?

What must happen inside the earth when a volcano erupts and sends forth molten, or liquid, rock called lava?

5. What is meant by Boiling?

You know that water boils at 212° F. What do you mean when you say that water boils? You mean that the liquid is changing rapidly to a gas. Water changes to steam at 212° F.

On the tops of high mountains water boils below 212° F. This is because the air is not pressing down so hard. People who live there have found that they must boil their food for a longer time than the people do who live at the foot of the mountains.



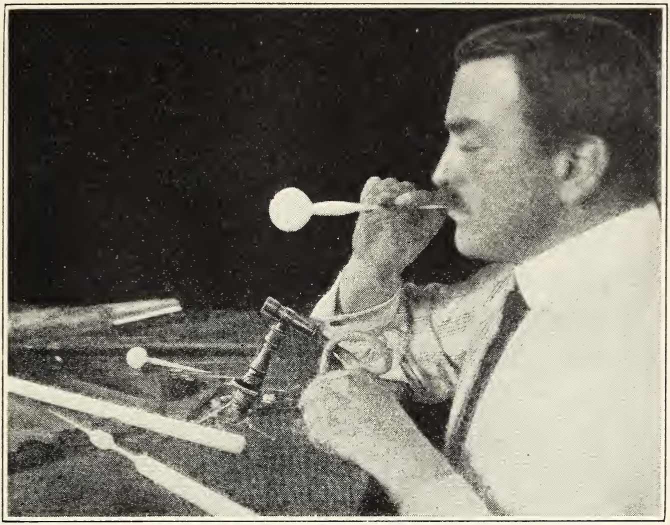
Teakettle with steam coming from the spout

Certain substances boil at a very low temperature, others at a very high temperature. The gases in our atmosphere boil at such a low temperature that we may never see them in their liquid state. It is fortunate for us that this is so. It never gets so cold that our air changes from a gas to a liquid. I am afraid we should have trouble to breathe it if it did. We can breathe only gases.

Even at the north and south poles it does not get cold enough for the air to become a liquid. Byrd and other explorers found plenty of air to breathe at the north and south poles.

When a substance boils it gets much larger. The steam from one teakettle full of water would fill 1700 teakettles of the same size.

Can you see why steam has such great power?



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In a glass factory. What is this man doing?

On the other hand, many substances, such as iron and silver, boil at such a high temperature that in everyday life we never see them as gases. What would happen if it could get so warm that metals would boil?

Things to Think About

1. What substances boil at a low temperature?

2. What substances boil at a high temperature?

3. Why is it a good thing that things do not all melt and boil at the same temperatures?

Problem 3 · Water

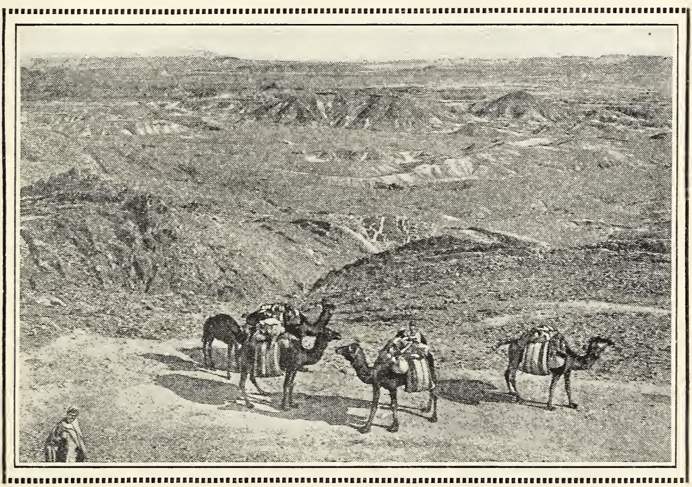
1. The Importance of Water to the Life of the Earth

Do you know what an oasis is? It is a place in the dry desert where travelers can find water and shade. Imagine how the people in the desert caravans watch and wait for the sight of these green spots!

If you stop to think what it means to travel mile after mile across the burning sands, you will begin to understand how welcome the bubbling spring water, the green grass, and the leafy trees are to the travelers. These men have carried their water in skin bags which were strapped to the camels' backs. The water gets hot and is not so refreshing as it was when it was cold. Still they drink it because they could not go on living without it.

A story is told of a wealthy diamond merchant who crossed the desert with many thousands of dollars' worth of precious stones. While crossing, his caravan got lost. They wandered about for days seeking, in vain, for an oasis. The supply of water became very low and at last there was no more. Still there was no oasis in sight. Just as they were about to give up hope, they sighted

An oasis in a desert. Where does the water that makes an oasis in a desert come from?



Camels and their drivers crossing a desert. Why are some places deserts?

another caravan on its way across the sands. The wealthy man was so delighted that he paid in diamonds for the water which was given him.

Let us see what there is about water that made the merchant willing to trade diamonds for it.

2. Water is Essential to Life

First of all, our bodies are about two thirds water. Scientists tell us that there is no substitute for water. Our blood is largely water. Much of the food we eat has a great deal of water in it. The liquids we drink are all made up largely of water. Water in the blood carries food to all parts of our bodies.

Besides providing a method of distributing food, water has also a cleansing power. We wash our hands and faces in it to clean ourselves on the outside. Water on the inside does a job of cleaning, too. It picks up all sorts of waste matter and carries it out of our bodies.

You can now understand why the doctor tells you to be sure to drink plenty of water. You can help your own body to keep well by giving it sufficient water to wash out the wastes and other things which would make you sick. Isn't that a little thing to do? After all, it is not hard to drink water.

We can do without food longer than we can do without water. People have experimented and have found that they could live many days on just water alone. This is because water carries through the body food which has been stored there.

From the very earliest times people have known how important a thing water is. At first people used jars made of clay or earth, bags made of the skins of animals, and natural objects, such as shells and gourds, to carry water. Even today, in some parts of the world, people must carry water for their needs.

All living things must have water. Man needs a great deal of it. He needs it for drinking, for bathing, for preparing his food, for carrying waste from his body, for cleaning his clothes, his home, his buildings, and his streets.

Most boys and girls know how important it is to keep their bodies clean. Some of them bathe every day. They know that when they play baseball, football, tennis, or other games that mean hard exercise, they perspire very freely. Perspiration carries waste material from the blood to the skin. Then, too, the body gets covered with dust and dirt. All this may make our skins rough. Bathing with warm water and soap helps to remove it and adds to our comfort. Everyone likes

to have as his friends people who are clean. A dirty person usually has few friends.

Some children like to take hot baths. Some prefer cold baths. A hot bath opens the pores of the skin. It increases perspiration. It makes the blood vessels that are near the surface of the skin expand, so that the body loses its heat rapidly. When the skin is in this condition, one must be very careful, for he may easily take cold. It is best to follow a hot bath with a cold one. This is especially true if one is going outdoors. The cold bath will close the pores of the skin. It will help to keep one from taking cold. A cold bath should be followed by rubbing and exercising.

One should stay in either a hot or a cold bath just a short time. In fact, there are some people who should never take a very hot or a very cold bath. A warm bath, neither too hot nor too cold, is very good for everyone.

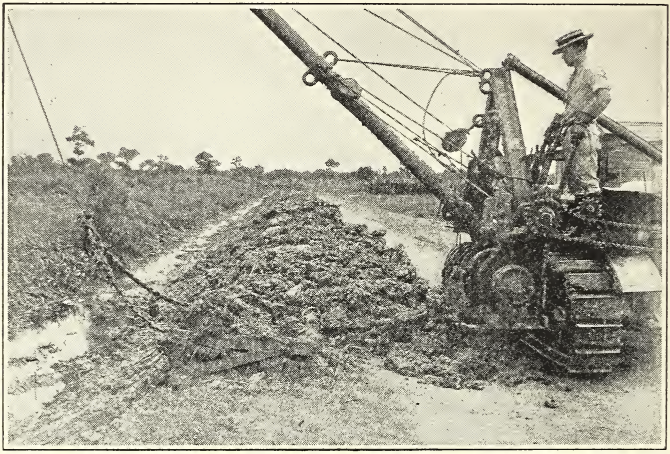
Water is as necessary for the life of plants and other animals as it is for man. Crops will not grow without rain. The rain sinks into the ground and dissolves materials which plants need in order to make food and grow.

Many farmers irrigate dry lands so that crops can be grown upon them. Much land which was formerly useless because it was too dry is now being used because it is being irrigated.

Rice growing in water. Rice needs more water than many plants. Do you know where rice grows in our country?

You must not think that all plants need the same amount of water. Some plants need very little. The cactuses of the desert can get along with little water, while onions, cabbages, celery, and rice need much water. That is why you will see these plants being grown in rich, damp soil.

Farmers often drain swamps and marshy lands and then plant crops there. They drain such places because the land has too much water for the plants which they wish to raise there. Do you know of any swampy lands near your home that have been drained? What use has been made of the drained lands?



This land was so swampy that the farmer had to drain it. How is he draining it?

3. The Dissolving Power of Water

We have been reading about water dissolving food. Just what is meant by this statement? Let us see.

Put a teaspoon of salt into a glass of water. Before you put it in the water, the salt was in the form of small, dry, white particles. Can you see these white grains after you put them into the glass? They soon disappear. They really break up into ever so much smaller bits — so small, in fact, that they become invisible. We say that they have dissolved in the water.

The strange thing about it is that the water *looks* the same as it did before. You would not know by looking at it that there was salt in it. There is one way that you can tell it has salt in it. That is by tasting it. If you taste the water, it will have a salty taste.

Do the same experiment with sugar. See if the white particles of sugar dissolve in water. Taste the water to see whether the sugar really becomes part of it.

You may wonder how to get the salt back again. Suppose that you want it back in the same form as it was when you put it into the water. Some of you may think this cannot be done, but it can. Boil the water until all of it disappears. Then look at the bottom of the dish. You will see salt particles in the dish.

If you live near the ocean you can get salt from sea water in the same way. Try boiling fresh water and see if you get salt in the bottom of the pan.

Not all substances dissolve in water. Powder a piece of chalk. Put this white powder into a glass of water. Does the white powder disappear? It doesn't break up into tiny bits and become part of the liquid. You can see the chalk particles. It does not change the water except to make it cloudy. We say that water does not dissolve chalk.

There are other substances which will not dissolve in water. Dishes will not dissolve in water. Books and coal will not. Make a list of other substances which do not dissolve in water.

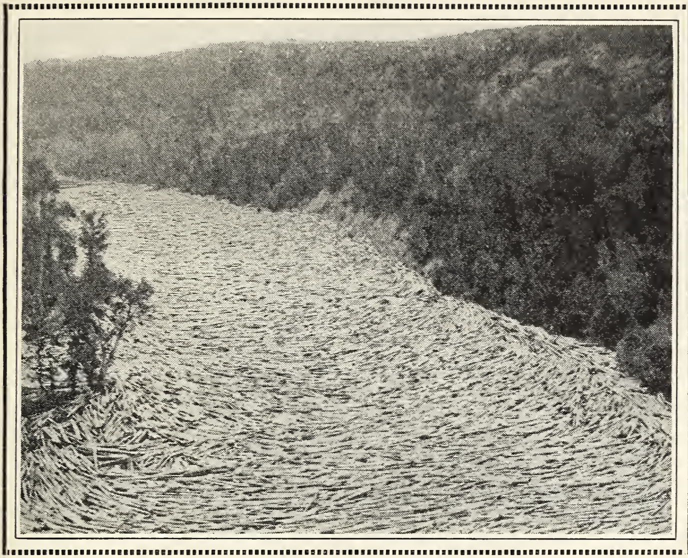
You know now why it is that sugar makes your cocoa or your cereal taste sweet. It is because it dissolves in the liquid. You also know what happens when you put salt in your soup. If sugar and salt did not dissolve, they would not change the taste of the cocoa and the soup.

It is fortunate that so many substances are soluble in water. When substances dissolve in liquids we say they are soluble.

Scientists say that water has changed the looks of the earth more than any one other force. It has carried things from place to place. Some of the material carried by it is dissolved in it. It is carried on to the oceans. Can you see why the oceans are salty?

The substances that water dissolves become invisible, except that some of them change the color of the water. Besides dissolving these substances, the water carries with it many things which are not soluble. Pebbles, sticks, sand, and logs can all be seen being carried along with the current of a stream. If these things were dissolved, they could not be seen.

Have you ever been surprised at finding how



Logs floating in a river. Why do the logs stay on the surface of the water?

different the water in another city tastes from that which you have at home? Do you know why?

Great underground caves have been formed by the work of water. The rocks which were soluble dissolved in the underground stream and were carried away. Where they once were, a cave was made. Caves would never have been formed if water had not been able to dissolve certain substances.

These caves are wonderfully interesting sights to see. Visit one when you have an opportunity.

©R. V. Davis

A cave showing its stalactites and stalagmites. Do you know which of these strangely shaped things are stalactites? How are they made?

You will see many strange tricks which water has played. It often leaves shapes in the rocks which remind you of people or animals, just as cloud shapes often remind you of things which you have seen.

Water not only dissolves bits of solid matter; it also dissolves certain gases. There is much oxygen in water. Fishes and other sea animals breathe the oxygen while swimming about. They could not live in water if there were no oxygen in it.

Here is an experiment you may enjoy doing.

Heat some water slowly in a glass flask or beaker. Watch the bubbles which form and rise to the top of the flask. Now let the water cool. Then taste it. You won't want much of it, because it will taste flat. The dissolved air has all left the water and gone into the air again. That is what those bubbles were that you watched rising as the water was heating.

Cold water holds more oxygen than warm water. This may explain why there are so many fish and other animals in the cold parts of the ocean.

4. Water as the Great Temperature Regulator

Perhaps your mother has a new gas or electric kitchen range. If so, she probably has a queer little round meter at the top of the oven. This meter is a thermostat. It controls the amount of heat which is wanted in the oven. If your mother is baking a cake, she sets the thermostat at a certain temperature, puts her cake in the oven, and then goes on with her other work. The oven will not be hot enough to burn the cake. It will stay at a certain temperature all the time.

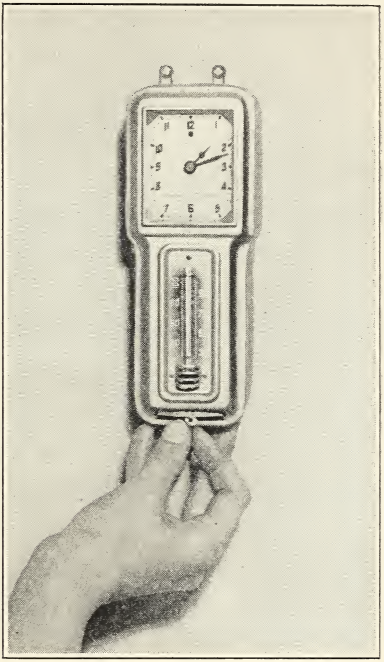
Perhaps you have a thermostat at home or at school which controls the temperature of the rooms in the same way. The thermostat is set at a certain temperature, 68° F. By the automatic control

A kitchen stove with a thermostat. Find the thermostat. Why was it placed on the stove?

of the thermostat the heat inside your house remains the same, no matter how cold the weather outside gets.

Water is a heat-controller, too. It does not control heat as the thermostat does your mother's oven or the furnace in your house; it does its work in a different way in the great outside world. Of course it cannot keep the temperature the same

all the year round, because the earth is so large. What it does is to modify the temperature; that is, it makes the summers cooler and the winters warmer than they would otherwise be. This may seem strange to you, but it is true. Let us learn why.



A thermostat. For what purpose is it used?

Water warms very slowly. Have you noticed that during the hot summer days the water you swim in is cool, while the sand on the beach is almost too hot to step on? You may have gone swimming in the early morning or late in the evening. If so, the water probably felt warmer than the sand you were stepping on. It really was warmer, because water changes its temperature much more slowly than many other substances.

Put a shining piece of metal out in the sun. If the day is warm and the sun is bright, the

metal will soon be too hot to hold in your hand. Would the water in a pan get as hot as that just by standing out in the bright sun? Metal heats much more quickly than water.

During the autumn months everything is getting cooler. Water in the lakes and oceans is cooling too, but very slowly. The air and the soil get cold long before the water does. As things cool they *give off heat*. When cold weather comes, the water is still fairly warm, or at least it is warmer than the air around it. As the water keeps on cooling, the heat which it gives off warms the air.

What happens in the spring? The warm sun changes the temperature of the air and the earth more rapidly than it does that of the water. When hot days arrive the water is still warming up. When things warm up, they take in heat. The water takes in the heat of the air and thus makes the surrounding air cooler than it would otherwise be.

Places near large bodies of water usually have warmer winters and cooler summers than places of the same latitude that are a great distance from lakes or oceans.

Since about three fourths of the earth's surface is covered with water, you can see what a very large part water plays in controlling the heat and

cold of the earth. It is a much greater temperature-controller than the thermostat on the gas stoves or on the furnaces in your houses.

5. What happens when Water Freezes

What happens when water freezes is really interesting. Most things get smaller, or contract, when they cool off. Water does, too. But when water turns to ice, it stops growing smaller and grows larger, or expands. It is lucky for us that this is true. If ice kept on getting smaller it would be heavier than water and would not float on it. When we wanted to skate we should have to wait until all the water in the pond had frozen solid. That would take a long time, for water cools slowly. Because ice is lighter than water, it freezes from the top down and floats upon the water beneath.

It is lucky for the fish and other animals too that ice is lighter than water. They could not live if this were not true. All the water would freeze, and they with it. As it is now, the temperature deep down in the oceans and deep lakes changes but little year in and year out.

The expansion of water when freezing does us some damage also. It breaks things as it tries to get room enough for the forming ice.

Things to Think About

1. Imagine what the earth would be like if water heated and cooled rapidly. Could you go bathing in the heat of summer? Would the earth be as pleasant and comfortable a place on which to live as it now is?

2. Why do farmers who grow certain fruits like to live near bodies of water?

3. Why are desert countries hotter in the daytime and colder at night than countries in the same latitude that are near large lakes or oceans?

4. Why would there probably be fewer plants and animals living in water that heated and cooled very rapidly?

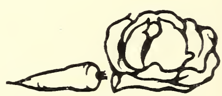
5. Suppose that three fourths of the earth's surface were land and one fourth water, what change would there be in our winters and summers? in our days and nights?

6. Which animals have greater changes in temperature, land or sea animals?

7. Why will water that freezes in bottles and pitchers often break them?

8. Why are the oceans salty?

Things to Do



1. See if there is water in the following foods: potato, carrot, lettuce, and bread. Heat pieces of these foods very carefully. Try to drive off all the water without burning them. How do they look?

2. Find out where the water you use in your home

comes from. How does it get to your house? How is it measured? Who pays for it?

3. You may have heard people speak of hard and soft water. Find out what the difference is between hard and soft water.

Reminders

Drink plenty of water each day.

Be careful to drink water that you know to be pure.

Do not drink water from a dipper or glass that is used by other people.

Have your own cup or glass or use a paper cup.

Bathe your body frequently, using warm water and soap.

Wash your hands often during the day.

UNIT IX

Plants

1. How Plants Grow
2. Herbs, Shrubs, Trees, and Flowers
3. How Plants find Places to Grow

PLANTS

What you read in Units VII and VIII told you about what living things need in order to stay alive. Some of the problems told you about water, light, and temperature. One of them told you that our light and heat came from the sun. Other units told you many things about the sun, the planets, and the moon.

The remaining units in this book again tell you about living things, about plants and animals. But the plants and animals that you may read about in the last units are not getting ready for winter. These units will tell you what plants and some animals do in the spring and summer, when the temperature is warm.

Have you ever placed some seeds on a moistened sponge and watched them grow? If you haven't, you will probably find it fun to try some or all of the experiments given in Problem 1. You will discover many things about plants in this problem. A very unusual thing about them is that they can make and store their own food. Read the problem and find out how they do it.

You may also like to know how herbs, shrubs, and trees differ from one another. Problem 2 will tell you what the difference is.

When you were in the woods or taking a walk in the country during the pleasant spring days, you may have wondered why you saw so few early spring flowers. You will not need to wonder about this after you read the story Miss Stone told to Joan and Ned.

Problem 3 is a most interesting one. In it you will find this question answered: How do plants find places to grow?

Joan and Ned showing their prize vegetables and flowers to their friends. What vegetables has Ned in his hands?

Problem 1 · How Plants Grow

1. Growing Plants

The exciting day had arrived at last. The prizes were to be given to the boys and girls who had brought from their own gardens the largest and best vegetables and flowers. No one seemed the least bit surprised to find many ribbons on the things that came from Joan's and Ned's gardens.

Joan and Ned were interested in raising the best radishes, carrots, nasturtiums, and petunias.

It was great fun for them to plan and lay out the beds and get the soil ready. They loved to see the tiny plants push their heads above the ground. It seemed strange that such wonderful things should come out of wee little seeds. They wanted to know more about plants. All sorts of questions came into their heads. Miss Stone asked them to write some of them in their notebooks.

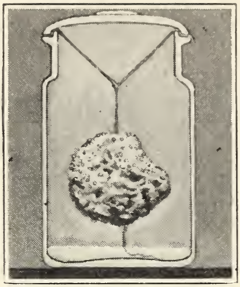
Here are some of the questions from their notebooks:

> What are plants?
> How are plants like animals?
> What are the parts of a plant?
> How do plants get their food?
> How do plants grow?
> How do plants make other plants
> of the same kind?

No matter how faithfully and carefully they watched their growing plants, the children soon found that they could not answer all their questions. They needed help; so they went to Miss Stone at once.

She suggested a number of simple experiments. She was sure that Joan and Ned would learn something from them. She was also sure that the children would carefully follow the directions that were given for each experiment. They would return with new questions to be answered.

Experiment 1. Put some bird seed or grass seed on a moistened sponge. Hang the sponge in a glass fruit jar. Cover the jar. After the seeds have sprouted, what do the roots do?



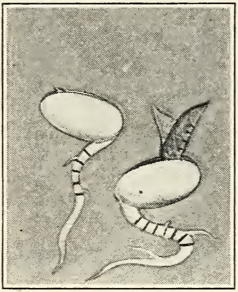
Experiment 1. Bird seed planted on a moistened sponge

Do you think gravity has any influence on the roots? Why do you think so?

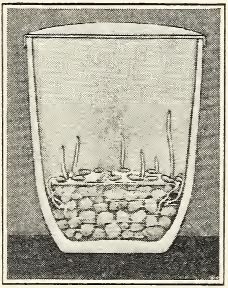
Experiment 2. This experiment is to show you where the roots grow.

Put two or three beans on wet blotting paper. Cover them with another piece of moist blotting paper. Then put them in a covered dish.

When the root of a bean is about an inch long, mark it off into small equal parts. Use pen and India ink for this. Return the bean to the moist blotters in the dish. After a couple of days look at the root.



Experiment 2. This picture shows where the root of a bean seed grows. The little plant is growing upward

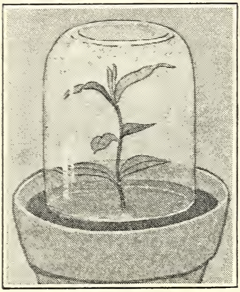


Experiment 3. The root hairs grow just back of the root tip

Where has it grown?

Mark the plant in the same way as it grows upward.

Experiment 3. This experiment will show you the root hairs. These hairs are very important parts of the root.



Experiment 4. Leaves giving off water in the sunshine. Small drops of water pass through the plant and collect on the inside of the glass

Put some pebbles and a little water in the bottom of a glass jar. Cover the pebbles with a piece of moist blotting paper. Put some wheat or other small seeds on the blotter. Do not let the water dry out.

Notice the little root hairs just back of the root tip.

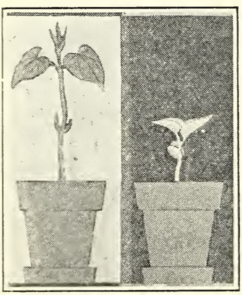
Why don't you see the root hairs when you pull a plant out of the soil?

Experiment 4. *Leaves transpire, or give off water, in the sunshine. This experiment will show you that they do it.*

Take any young plant growing in a flowerpot. Cover the plant with a glass jar and place it in a sunny window.

Look for the small drops of water on the inside of the jar.

Where did the water come from? How did it come?

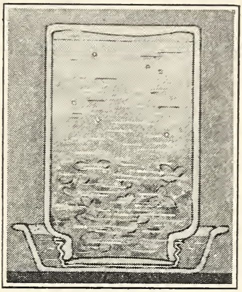


Experiment 5. Can you tell which plant grew in the sunlight?

Experiment 5. Plants need sunshine if they are to grow big and strong. Put some seeds in two different flowerpots filled with soil. Keep one in a sunny window. Keep the other in a dark closet or room. Let the plants grow for a few weeks. What has happened? Why?

Experiment 6. *This experiment will show you that oxygen gas is given out through the leaves of plants.*

Pick a number of small green leaves — clover leaves will do. Half fill a bottle or fruit jar with them. Then fill the jar with water.



Experiment 6. Bubbles of oxygen gas are collecting in the jar

Next cover the jar with a flat piece of glass and turn it upside down in a pan of water. Remove the piece of glass and put the pan in the sunlight.

If you collect many bubbles of oxygen, cover the mouth of the jar with the piece of glass and take it out of the pan. Stand the jar right side up. Quickly put a glowing match or a stick with a glowing spark on its end in the jar. What happens? Why? Oxygen is a gas that is found in air. It helps things to burn.

For the next couple of weeks Joan and Ned were very busy. They tried all the experiments suggested by Miss Stone. In their notebooks they made drawings of the plants as they saw them. They wrote short stories about the things that happened. But they still wanted to know more about plants than their experiments showed them. They wondered if large trees had to begin as tiny little plants.

With the help of Miss Stone they found the answers to most of the questions that bothered them.

2. What the Children Found Out

They learned that plants are living things. In many ways they are like animals. They must have food. They must have warmth. They must have light. They must take in and give off air. They use energy. When we are warm we perspire, or give out water through our skin. Plants do this, too; but we say that they transpire, because they do not get warm the way we do. Plants very seldom live alone. They live in communities, as we do. The plants that like the same kinds of things are usually found living together. Plants cannot move about as animals do. Neither can they feel. They can't think, because they have no minds.

Joan wanted to know what would happen if there were no plants on the earth. Man and the other animals would soon disappear, because they couldn't get any food. Some animals live on plants. Other animals live on the animals that feed on plants. So plants are really needed by animals.

Can you name some animals that eat plants? Can you name some that feed on other animals?

Plants supply enormous quantities of food for man and the other animals. They supply many kinds of materials that man needs for his home and for his clothes. They make wonderful hiding places for all kinds of wild animals.

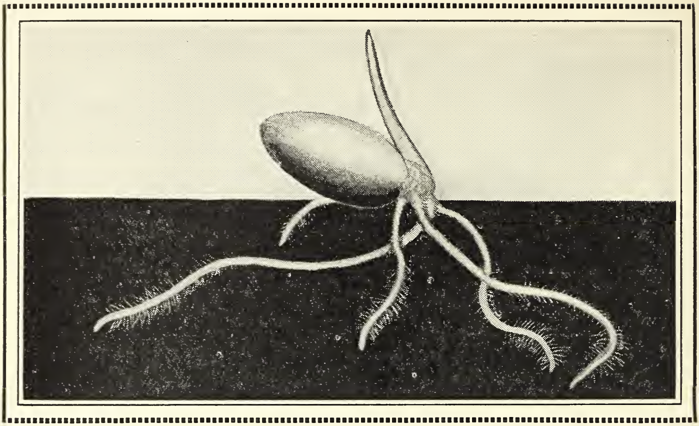
Would all the plants disappear from the earth if there were no animals?

No. All plants that have green coloring matter can make the food that they need in order to live and grow. They can put together certain things that they take from the air and from the soil, and make food out of them. They must have sunshine to help them. Animals cannot do this. They must use food that has been made.

From their work in their gardens and their experiments the children knew that the parts of the plant were the root, stem, leaves, bud, flower, fruit, and seed. They had seen all these parts. They knew that the root held the plant firmly in place. It searched for water. It absorbed water and mineral salts from the soil. It stored some food for the use of the plant later on.

They found out that some plants have fleshy roots. These roots are able to store a lot of food. They store up a lot of water too. Storing up water in the roots is more important for many plants than storing food. In desert places plants often have tremendous roots, and stems too, for storing up great quantities of water. They use this water during dry seasons.

Joan and Ned had seen great fields of alfalfa when they visited their uncle. They were surprised to learn that the alfalfa plants sometimes



The tiny root hairs may be seen on the roots of the plant in this picture

send their roots down twenty feet searching for water. The drier the region, the deeper the roots must go. These facts made the children see how necessary water is for plants.

3. The Roots absorb Moisture from the Soil

Experiment 3 helped the children to see that roots did take in moisture. They noticed that the root grew downward to the water. Then they saw the little root hairs appear near the growing tip of the root. Water and mineral matter are absorbed mostly through the root hairs. Many of these little hairs last only a few days. New root hairs come as the root grows in length. The old

ones die. When a plant is pulled up by the roots, the tiny root hairs are nearly always broken off, because they cling so tightly to the soil. The growing tip of the root is protected by a root cap.

4. What the Stem Does

The little stem grows in the opposite direction to the root. It pushes its way upward. It must do this because it is going to hold the branches and the leaves, and the leaves must be held up to the sunlight. The stem connects the roots and the leaves. It carries the water and dissolved mineral salts from the roots to the leaves. It carries food prepared by the leaves back to the roots. Some food is stored in the stems.

5. How Plants make their Food

This was one of the most important questions on the children's list. Joan and Ned couldn't answer it by watching the plants in their garden. Neither did their experiments help them. Ned thought plants got all their food from the soil through their roots and stems. Miss Stone told him that this was not true. Plants get water and mineral salts from the ground. That is all. But they could not live and grow without other food; so the leaves become a factory and make it. No

factory can make something out of nothing. It must have raw materials. The raw materials which the leaf factory uses are the water and mineral salts which come up through the roots and stem, and carbon dioxide which the leaf takes out of the air. All factories must have power, or energy, to start their machines working. Sunlight is the energy used by the leaves in their food-making work.

The children had learned that air is made up of certain gases. One of these gases is carbon dioxide. Leaves need carbon dioxide for their food-making. So they take it in through tiny openings in the leaf, called pores. In the sunlight the water and mineral salts that come up from the roots of the plant unite with the carbon dioxide in the leaves. And in this way the starches and sugars which the plants need are made. The making of food in this way by the leaves is called photosynthesis.

No doubt this was a new word for Joan and Ned. But they had just been reading something about it. They found that *photosynthesis* comes from two Greek words that mean "light" and "putting together"; so it means putting together in the light.

Then they found another new word, *chlorophyll*. And they wondered what *it* meant. It's the name of the green coloring matter in the leaf.

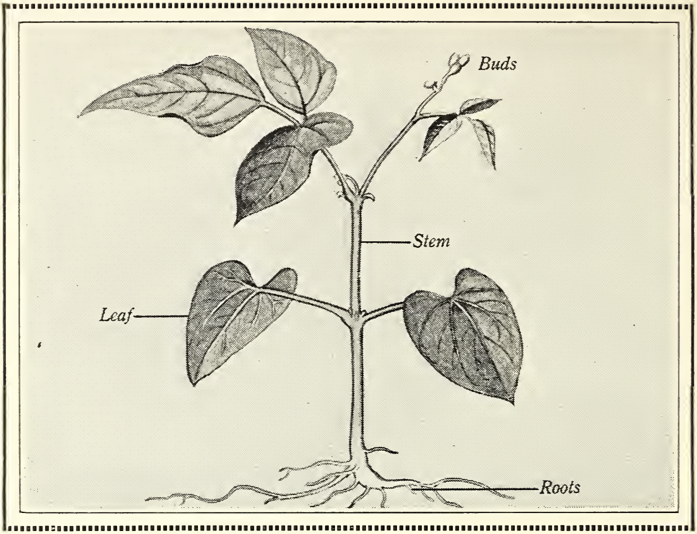
Even though they had sunlight and carbon dioxide and water, the leaves couldn't make the least bit of food without chlorophyll, the green coloring matter. Isn't that strange? Just how chlorophyll helps with the work of photosynthesis, no one knows. It is one of the plants' secrets. We do know that plants that haven't chlorophyll cannot make their food.

Leaves do their best work in the summer. If it is very, very warm and the temperature is 100° F. or over, the whole leaf factory slows down. During the cold winter no food is made.

Other things are happening while the leaves are making starches and sugars. Oxygen is made too, and it passes from the plant into the air. More water comes up to the leaves than is needed in making food. Some of it is transpired, or goes into the air.

Animals and plants help each other. Animals give out carbon dioxide. Plants take it in. Plants give out oxygen. Animals breathe it in. Plants give out a small amount of carbon dioxide too.

Plants do not store food in their leaves except for a very short time. There would not be room for it. Leaves make food very rapidly. This food cannot be carried from the leaves so quickly as it is made; so some of it remains in the leaves. At night no food is made, but the small amount of



This picture shows most of the parts of a plant. Can you tell what each part does?

it that is in the leaves continues to pass on to the other parts of the plant. In the morning the leaves are ready to begin their food-making again.

Plants in cities have great difficulty in making all the food they need. Smoke, dust, and soot collect on the upper surfaces of the leaves. A great deal of sunlight is shut out from the leaves because of this.

Roots, stems, and leaves are important parts of the plant. All the food needed is obtained by means of them.

Flowers, fruits, and seeds are important, too. They may come later in the life of the plant. These parts help the plants to make other plants.

You have been reading about the things that plants need in order to make their food and to grow. Man also needs things so that he may live and grow. He must have the foods that will make him grow. He must have the foods that will repair the worn-out parts of his body. The foods that do this are called proteins. Lean meat, milk, eggs, whole-wheat bread, beans, and peas are some of the foods that contain protein.

Man must have foods that will give him energy and will keep his body warm; so he eats those that have starches and sugars in them. All the grains, fruits, and many of the vegetables contain starch and sugar. Starches and sugars are called carbohydrates.

Many of the foods that man eats contain fats. These fats also help to produce energy. Some fats are often stored in the body for use when needed. Can you name some foods that have fats in them?

The teeth, the bones, and the blood must have a special kind of food to build them and keep them in good condition. The mineral foods help to do this. Almost all foods have mineral substances in them. Some have iron. Some have lime. Man

adds salt, another mineral, to most of his foods. Then, too, he gets a great deal of water in the foods that he eats.

In order to keep well and strong it is very necessary that we should eat some food containing protein, carbohydrates, and minerals each day. Milk and eggs, fresh, ripe fruit, whole-wheat bread, and the green leaves of lettuce, cabbage, and spinach are excellent foods.

Have you ever heard or seen the word *vitamins*? Vitamins are food substances that have recently been discovered. We know very little about them. We can't see them. But they seem to be very necessary parts of our food. People who are interested in studying foods found out about vitamins by experimenting with the feeding of rats, chickens, and other animals. They found that these animals grew very much faster, and were stronger, when vitamins were added to their diet.

Here is a good rule to follow each day.

Eat some fresh, ripe fruit; eat a green, leafy vegetable; eat another vegetable, such as tomatoes, string beans, peas, or carrots; drink a quart of milk; and drink several glasses of water. If you do this, you will get all the vitamins you need.

Things to Think About

1. Have you ever seen a potato or an onion that had sprouted in a dark closet or in the cellar? How did it look?

2. How long do you think the little potato plant would live in the dark closet? Why?

3. Why does grass look white or yellow when it grows under a board or log?

4. Suppose you should strip a plant of all its leaves. What would happen?

5. Why do trees often look so much fresher and greener in the country than in the city?

6. How does your food depend upon the sun?

7. What is photosynthesis?

8. What is chlorophyll?

9. These plants are used for food. Can you tell what part of each plant is eaten?

Potato	Pear	Lettuce	Corn
Spinach	Tomato	Carrot	Cabbage
String bean	Cauliflower	Turnip	Squash
Lima bean	Brussels sprouts	Broccoli	Celery

10. Here are two facts about plants. Can you write five other sentences, beginning them with the same word?

Plants supply food for animals.
Plants give oxygen to the air.

Things to Do

Plant some seeds in two different window boxes containing different kinds of soil. Find out —

1. The kind of soil the plants like best.
2. That plants need light.
3. That leaves will turn to the light.
4. That plants need plenty of water.
5. That some plants grow more rapidly than others.

How to make a Blue Print of a Leaf

1. Get blue-print paper and a blue-print frame. These may be purchased where photographers' supplies are sold.

2. Select a perfectly formed leaf.

3. Place the leaf in the frame next to the glass.

4. Put the blue-print paper in the frame next to the leaf. Be careful not to expose the blue-print paper to strong light while you are getting the leaf ready. It is best to work in a darkened room.

5. When the leaf is firmly fixed in the frame, place it in the sunshine.

6. If the sunlight is strong, expose the leaf from three to five minutes. You will probably notice the blue paper changing in color.

7. Remove the paper from the frame and dip it in a pan of clear, cold water. Then spread it on a flat surface to dry.

8. Put your blue print in a portfolio or scrapbook.

Problem 2 · Herbs, Shrubs, Trees, and Flowers

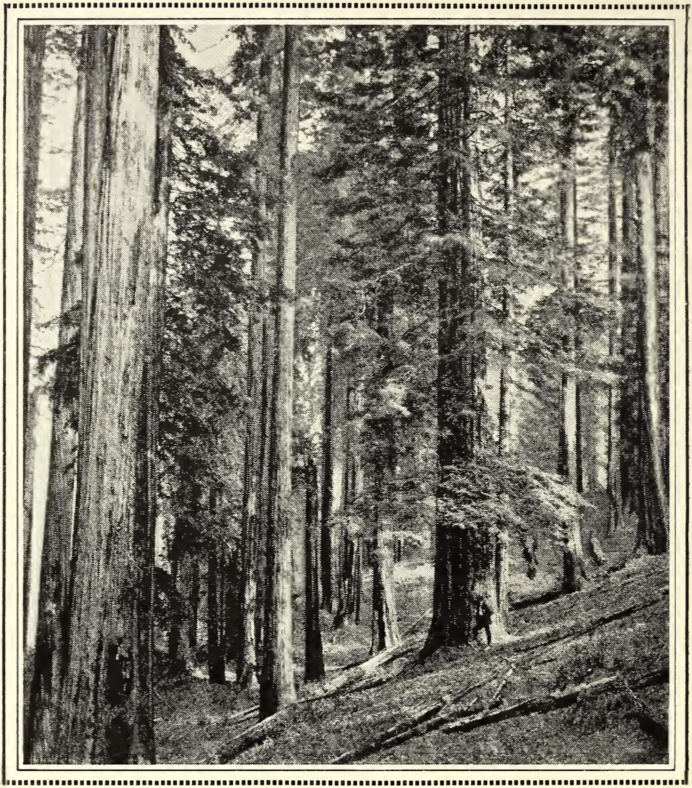
1. Herbs, Shrubs, and Trees

Herbs are small plants. They are much smaller than shrubs and trees. They are easily broken, because they are the weakest plants. When winter comes, the part of the herb above ground dies. The root may live and send up a new plant each year.

Shrubs are not so large as trees. They have many stems, or little trunks, that grow from a single root. These stems are almost the same size and are slender. Shrubs are sometimes called bushes.

Trees are woody plants. They need a much longer time in which to grow and ripen their fruits than other plants. The stem of the tree is called the trunk. Think how strong it must be to bear the weight of all the branches and leaves!

All plants that have green leaves live, grow, and make their food in the same way. Some are tiny plants that are flat and circular and float on the water. Some of them live only a few weeks. Others are great trees, many of which are over three hundred feet tall and have enormous trunks. They have lived hundreds of years. The oldest living thing on the earth today is a tree.



Some of the large redwood trees of California. How old do you think these trees are?

Trees grow from the tips of the roots and the tips of the branches. In this way the tree becomes taller and broader year by year. Its roots go deeper and spread out farther. A layer, or coat, of new growth covers the whole tree.

Trees that live close together influence one another. The stronger trees grow tall and straight. The weaker ones become dwarfed, and they sometimes die.

See if you can find a log or a tree stump that has been sawed straight across. Look closely at it. Do you see the circular rings running around the log? Count them. How many do you find? Each one of these rings means a year's growth. How old was this tree when it was cut down?

A cross section of a tree. Count the rings running around the log. What do these rings tell?

In the center of the log we find the heartwood. The heartwood is no longer living. Its small cells often become clogged up, and the wood turns dark.

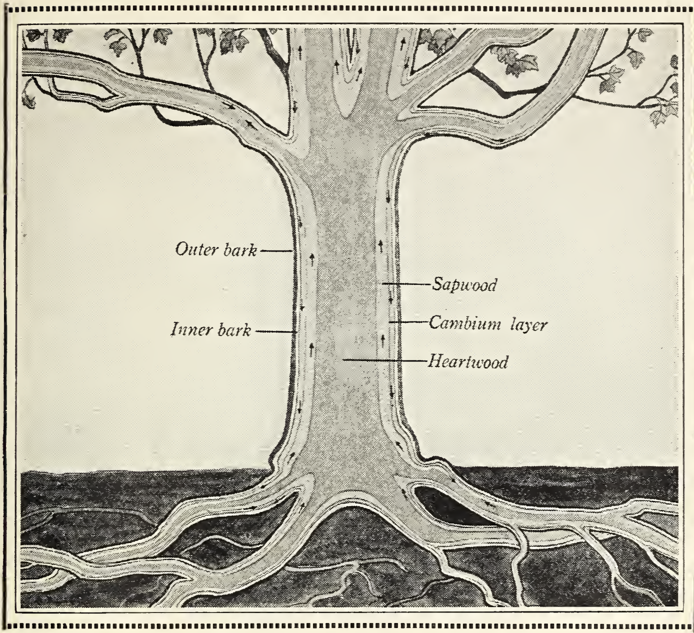
The sapwood is very much alive. It is next to the heartwood. The water passes up through the sapwood on its way from the root to the leaves. It is a very important part of the trunk.

The tree has two barks, the outer bark and the inner one. The food which is prepared in the leaves passes downward through the inner bark to

Can you tell which of these trees is the sycamore? How does it differ from the birch?

the branches and roots. Between the inner bark and the sapwood the trunk increases in size. Here the new ring of growth is formed each year. It is called the cambium layer.

The outside bark is dead. As the tree increases in size, the outer bark becomes too tight; so it splits and forms the furrows and ridges that you see in old trees. Sometimes the bark comes off in scales. The sycamore's bark scales off, but the bark of the birch tree peels off.



This picture shows the circulation of the food in the tree. Can you trace the water and food as they circulate up and down in the tree?

2. Flowers

From early spring until late autumn, flowers bloom in the woods, in the marshes, in the fields, and along the roadsides. Almost everywhere one looks, some bright bit of color may be seen.

Flowers are a very necessary part of many plants. The fruit, which contains the seeds, has its beginning in the flower. Without flowers plants would not be able to make seeds. And without

Poison ivy is a climbing vine. You should learn to know it and avoid it. The leaf consists of three leaflets, which are red in early spring and late fall

seeds, in turn, many plants might not be able to begin their growth.

Most of the flowers that bloom in early spring are small. They haven't the strong, brilliant coloring of the late summer and autumn flowers. Their colors are white or delicate tints of pink, lavender, yellow, or blue.

The plants that have these flowers must begin to make their food very early. Many of them grow in the woods or in shaded places. When the leaves come out on the trees, the sun does not

A field of daisies. Did you ever see so many daisies in one field? The story tells you why there are so many

shine on the floor of the woods. The tiny flower plants can get no sunshine; so they must go to work before the leaves of the trees shut out the sunlight. They have only a short time in which to make their food. After the leaves appear on the trees, the little plants become inactive. Some of them rest until the next spring.

Many of the summer and autumn flowers grow in fields and along roadsides. I'm sure you have seen fields covered with Queen Anne's lace, daisies, asters, and goldenrod. There seem to be more and more of them every year. The plants that bear

Joan and Ned are going to the woods to see the first hepatica of the spring. Sometimes hepatica blooms before the snow has gone.

The flowers of the skunk cabbage. Of what use do you think the hood is to the flowers?

these flowers are strong and sturdy. They grow out in the open places, where they can get all the sunlight they need. Then, too, they have hundreds and hundreds of seeds, with little sails that carry them off and drop them in many places.

Flowers and trees help to make outdoor places beautiful. They should be cared for and protected.

3. Flowers — Help to Save them

Spring had come. The sun was growing warmer. The buds on some of the trees were beginning to swell. Many of them were almost open.

Hepatica. This is one of the earliest and loveliest of our spring flowers. The flower blooms before the new leaves come out

The spring made Joan and Ned long to be out of doors. The cheery songs of the first robin, the first song sparrow, and the first bluebird had greeted them from the roadside. Down by the brook a skunk cabbage had pushed up its head.

Joan and Ned crossed the brook by stepping carefully from stone to stone. They wandered off to the woods to find the first hepaticas of the spring. They knew where to look for them. They had always found them in the warm, sheltered corners of the moist woods. Probably the last lingering snow of winter would be all about them.

Trailing arbutus is one of the very beautiful spring flowers. Its leaves are thick, and it has a woody stem

The children hunted a long, long time today before they saw a single flower.

Ned found the first one. It was peeping out of its bed of thick brown and purple leaves. The children looked at it with joy. It seemed so warm and cozy and furry. They did not disturb it. Then they made a careful search of the woods for others, but they found only a few plants.

Joan was discouraged. "There were always so many here before, Ned. What do you suppose has happened to them?"

Ned suggested that they should ask Miss Stone

about it. She might know some reason why there were so few this year.

This is what she told them. She thought it would help them to understand why they found fewer flowers this year.

Children, and grown people too, take walks in the country. They love to go on picnics. They play games, eat their lunch, and have a good, jolly time. Suddenly someone sees a flower, then another, then a whole lot of flowers. In a short time everyone is picking. Each one is trying to pick the largest bunch. Soon not a single flower is left. In their eagerness to have the largest bunch, many people have pulled the whole plant, root and all, out of the moist earth. Then someone may see a dogwood tree in full bloom. In a short time it is stripped of most of its branches and is left a complete wreck in the woods.

When the time comes to go home, most of the flowers are wilted. They are not worth carrying away; so they are thrown away. Would it not have been better to let them stand where they were so straight and lovely? Other picnic parties might like to see them.

For a long, long time, people have gathered all the wild flowers they wished. The country places near the cities have been stripped bare. Many of our most beautiful flowers can no longer be found

because of careless picking. It is no longer possible to find the lovely trailing arbutus in many of the places where it used to grow. Dogwood and bittersweet are being picked every year. It will soon be difficult to find them.

THE OUTDOOR CODE

HELP save the Trees and Wild Flowers,
Protect the Birds and Game,
Keep the Highways Beautiful,
Pick up the Picnic Rubbish,
Put out your Fire; then bury it.

Wild Flower Preservation Society, Inc., Washington, D. C.

You may see this poster in many places. Why is this poster needed?

Would spring be spring to you without the robin and the bluebird and their songs? For many of us there would be no spring without the dainty flowers of the woods. We protect our birds. Flowers are living things, too. They should have a chance to live.

Joan and Ned thanked Miss Stone. They now knew what had probably happened to their precious hepatica. They hoped that nothing would disturb the few plants they had found.

Things to Think About

1. How many of these early spring flowers do you know?

Skunk cabbage
Hepatica
Spring beauty
Bloodroot
Trailing arbutus
Dutchman's breeches
Yellow adder's tongue
Marsh marigold

2. Here are some *if's* to think about. Can you answer them?

a. If most or all of the flowers are picked, where will seeds for new plants be found?

b. If plants are pulled up by the roots and thrown away, what will happen?

c. If the whole jack-in-the-pulpit plant is picked with the flower, how is the plant going to make its food?

d. If fruit dealers continue to decorate their stands and baskets with branches and leaves of laurel, what will happen to the laurel bushes?

e. If we wish to continue to decorate our homes at Christmas time with beautiful greens and holly, what must we do?

f. If we see the flowers in the woods and fields and along the roadside and are satisfied to let them stay where they are, what will happen?

Things to Do

1. Make posters asking for help in saving the dogwood and other wild flowers.

Problem 3 · How Plants find Places to Grow

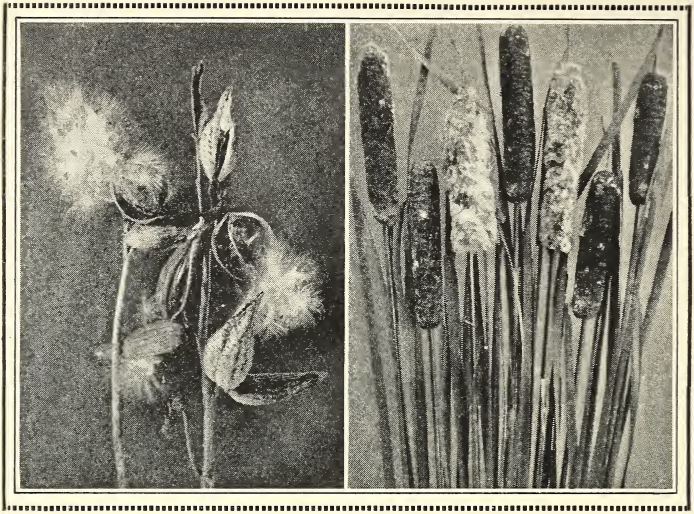
1. Seeds that have Sails

You have learned that many animals take care of their young until the young are able to take care of themselves. Many animals can move about with their young and protect them from harm.

Plants cannot do all the things that animals do. The big plants cannot give the seeds or small plants the kind of care that animals give to their young. They cannot travel from place to place with their seeds, because they are held fast in the ground by their roots. But plants do give their seeds wonderful little bodies, so that they may travel about by themselves. There are seeds that can travel long distances through the air. There are seeds that can travel on the water. There are seeds that can travel on the land.

Many of the seeds that travel through the air have little feathery sails. These sails are very light. The gentlest breeze will start the seeds on their way. Dandelion seeds have little sails.

Have you ever played with the lovely white heads of the dandelion? Sometimes boys and girls like to blow these white heads to see the seeds, with sails all set, fly away. They look like tiny parachutes as they go through the air. Think of



Milkweed pods (left) opened and closed. Cat-tails (right) grow in swampy places. Find the seeds that are ready to fly away

the great number of tiny seeds in the head of each dandelion. Sooner or later some of these seeds reach the ground, and the young plants begin to grow. Do you wonder that there are so many dandelions on our lawns?

Have you ever gathered milkweed pods? If you have, and if you kept them until the pods opened, you probably were surprised to see so many little brown seeds. These seeds are packed together very closely in the pod, but each one has its own little sail. Some day it will fly away with the wind. It may find a place in the soil and begin to grow.

Many of you have seen and can call by name goldenrod, cat-tails, and thistles. They also have hundreds of seeds with little feathery sails, and these seeds fly off and are scattered by the wind. There are other seeds that have sails, too, but their sails are not at all feathery. They are large, stiff, and firm. These seeds glide away in the wind. Some of these sails are very much like wings. The seeds that have them are often called winged seeds. These seeds are much heavier than the small fly-aways. The wind doesn't blow them very far away from the big plant. Some people call some of these seeds *keys*. Most of these winged seeds are found on certain tall trees. The maple, ash, catalpa, ailanthus, and pine are some of the trees that have these seeds.

2. Seeds that Jump, Slide, and Tumble

There are many seeds that do not have sails to catch the wind and help them on their travels, but they have other means of getting away. Some seeds are jumpers. They jump out of their pods. There seems to be a little explosion, the pod opens, and out pop the seeds. Violet and witch-hazel seeds are scattered in this way.

Did you know that some seeds slide over the frozen snow and ice? The seeds of the honey-locust

Honey-locust pods sliding about on the ice

trees may do this. When I was a little girl, we used to play hockey on the ice. The honey-locust pods were our pucks. The long, brown pods would often stay on the trees until midwinter. Then they were tossed about by the wind over the ice and the frozen snow. The pods were broken, and the seeds fell on the ice. In the spring the seeds sank into the soft, wet earth, far away from the mother tree.

There is a plant that has a most amusing way of scattering its seeds. It is the tumbleweed. It is well named, for it tumbles along on its way. When its seeds are ripe, the whole tumbleweed plant breaks off near the root. Then a strong wind catches it, and off it starts. It tumbles along, scattering its seeds as it goes.

Here is the tumbleweed, scattering its seeds as it tumbles along

3. Other Seeds

Have you ever taken a walk along a road, in a field, or in a wood and found that your clothes were covered with burs and other kinds of sticktight seeds? You didn't like them one bit. What did you do? I think you did what most people do who find these seeds on their clothes. You stopped, picked them off, and threw them away. By doing this you were helping these sticktights to travel from place to place. These seeds have little sharp hooks which help them to take hold of things. They often get into the wool and the hair coverings of sheep, cows, dogs, and other animals. The animals don't like to have them, either. They rub, and scratch, and pull, to try to get them off. So they too help these sticktights to get away.

Coconuts floating on the water. Do coconuts grow where you live? Why?

Sometimes seeds drop into the water of brooks and streams. They drift along with the current until they find a place where they may lodge and begin to grow. Often seeds that float in this way become water-soaked and decay. There are certain seeds that are not injured by being in the water a long time. This is true of some kinds of asparagus seeds.

The coconut floats on the sea. Its outside covering makes it light, and it floats along easily. It may float hundreds of miles, and grow where the waves wash it ashore.

Nuts are heavy seeds. They usually drop from the tree to the ground. Some of them may remain

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This squirrel is eating a nut from his winter hiding place. Where do you think he hid his nuts?

under or near the tree that they came from and begin to grow. Others may roll long distances away. This happens when the nut tree is on the slope of a hill.

Many animals carry seeds, especially nuts, away from the mother plants. Squirrels and chipmunks help many kinds of nuts to travel about. They usually gather and hide more nuts than they need. The nuts that are not eaten may grow in time into little trees.

Berries and juicy fruits are very attractive to many birds. Sometimes the birds carry the berries and fruits a long distance. Then they may eat

These pods open and sprinkle their seeds over the ground

only a part of them. The part that is not eaten drops to the ground. The little seeds that are in it find new places in which to grow. Birds often eat hard, dry seeds which they cannot digest. These seeds pass through the bird's body without being harmed. They may be dropped by the birds far away from the plants on which they were found.

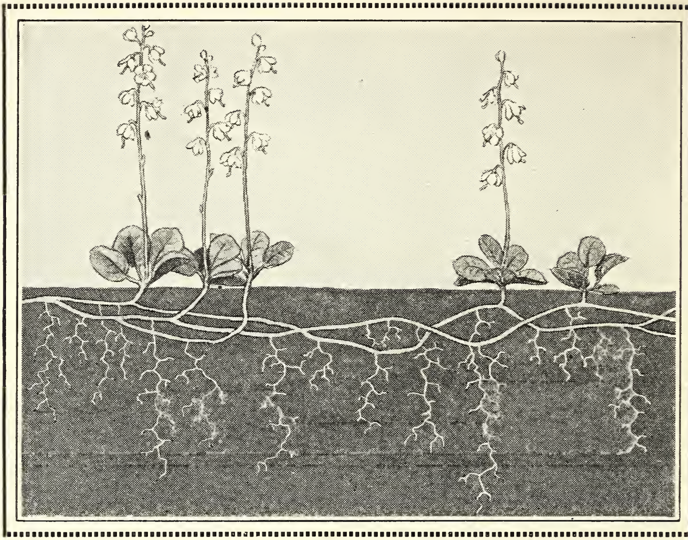
Ants help to scatter seeds, too. They are really very useful in scattering some of the smaller ones. They seem to like the oily part of certain seeds, and they roll them away from the plant to their nests. Sometimes many of the seeds are left on the way. Bloodroot, wild ginger, and false mermaid weed are often scattered by ants.

Some plants have very tiny seeds. You can scarcely see them, they are so small. There may be hundreds of them in one pod. When the pods

Along this stone wall you see ailanthus trees. Our first ailanthus trees were brought from countries in Asia

open, the little seeds are sprinkled over the ground or shaken into the fur of a passing animal. Poppy seeds are scattered in this way.

People have helped plants to travel nearly all over the world. They have carried seeds from place to place and planted them. They did this



Wintergreen travels from place to place by means of underground stems. The picture shows you how this is done

because they wanted seeds and plants for their food, their clothing, their homes, and their pleasure. They carried the ailanthus and the gingko trees from the far-away countries of Asia to America. Many seeds and trees were brought from Europe to the New World. People now have many ways of carrying seeds great distances. They carry them in wagons, in automobiles, in trains, in boats, and in airplanes.

You may have helped many fruits to scatter their seeds. When you ate an apple, a peach, a pear, or some other fruit outdoors, what did you

do with the seeds? You threw them away. By doing this you were helping these seeds to find new homes.

4. Runners and Underground Stems

Some plants find new homes with the help of runners. These plants put forth long, slender shoots which lie along the ground. These take root and form new plants every few inches. Strawberries and many other plants spread quickly in this way.

Other plants migrate by means of underground stems. In the smaller plants these stems grow near the top of the ground. In the larger plants they grow much deeper. Young plants grow from these stems at different places. Plants such as wintergreen, some kinds of grass, asters, willow trees, and poplar trees migrate in this way.

When plants are already growing so thickly that seeds or runners can hardly find a place to grow, tiny shoots from underground stems can push themselves up and grow.

Things to Think About

1. What would happen if every seed of every plant on the earth should grow?

2. Why doesn't every seed grow into a plant?

Things to Do

1. Collect as many seeds of plants as you can.
2. Put your seeds in these separate groups:

    Seeds that have feathery sails
    Seeds that have stiff sails
    Seeds that have hooks
    Heavy seeds, like nuts, that roll
    Seeds that jump
    Seeds that are tossed about on the ice

UNIT X

Forests

1. What Forests Do for Us
2. Caring for our Trees

FORESTS

How should you like to live in a place where there were no trees, where you would see only bare earth and stones and buildings?

Such a place would be dreary and not very restful. We shouldn't like it. But there are boys and girls who do live in just such places. When they see trees for the first time, they want to know what they are, how they are used, what is done to care for them.

There are many, many things to tell about trees. To tell all we know would take a long time. Then, too, there are a great many things about them that we do not know.

The next two problems tell some of the things that we know our forest trees do for us. They also tell some of the things that we must do for our trees. You will find a number of things that you yourself can do to help take care of our trees.

Problem 1 · What Forests Do for Us

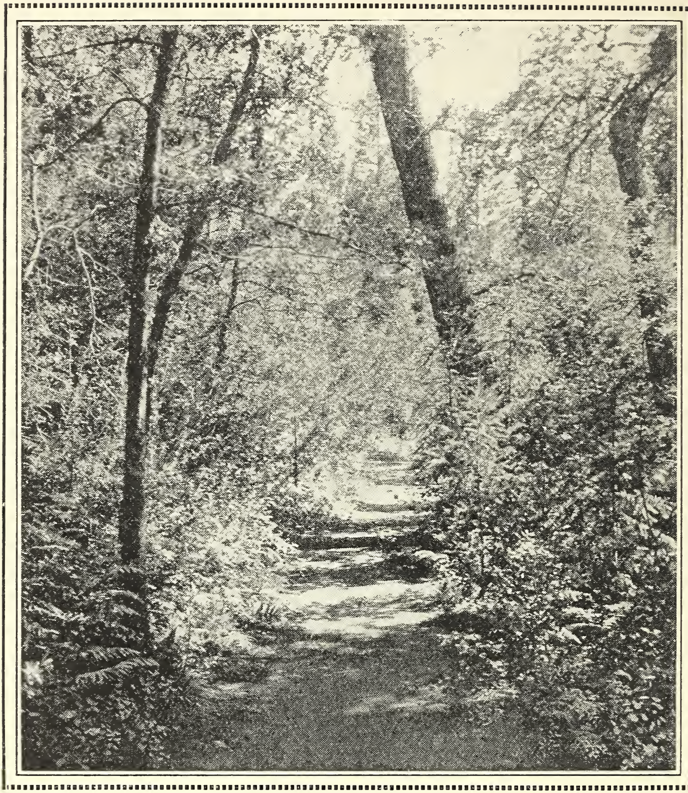
1. What Forests Do to the Soil

You probably live where you can see many trees. If you travel only a short distance from your home, you see great stretches of land covered with trees. Such places are called forests.

A forest is made up of a great number of trees. The trees often stand so closely together that their tops look like a beautiful green roof. In the forest you will find tall trees and spreading trees, old trees and young trees. Shrubs and bushes are often found growing under the trees. Beautiful ferns and mosses frequently cover the ground. Often there is a little stream that sings on its way. Its water is almost always clear and cool. You like to take off your shoes and stockings and wade in it. Birds and many other wild animals make their home in the forest.

There are forests of deciduous trees and forests of evergreen trees. The deciduous trees are those that lose their leaves in autumn and remain bare all winter. What deciduous trees do you know? What evergreen trees do you know?

Does it seem queer to you to speak of the floor of the forest? The floor of a deciduous forest is usually covered with small plants and bushes. In



A deciduous forest. Can you name some of the trees that grow in a deciduous forest?

evergreen forests the needles fall from the trees and cover the ground. There is often such a thick carpet of needles that seeds do not get a chance to grow; so there is very little undergrowth in a forest of evergreens.

Did you ever look closely at the soil in a wood or forest? Did you ever feel it?

It's almost always spongy, moist, and black. It is called humus. Humus is mostly, but not wholly, decayed vegetable matter. It is often used by growing plants. In some forests one may dig deep, deep down and still find this rich, black soil.

Rocks break and crumble and make soil. They make mineral soil. But most plants grow best in soil that has a lot of humus in it. Trees are very important in helping to make humus. Many of their leaves and twigs fall to the forest floor and decay, and this helps to make humus.

Some of the best farm lands in the world were once forests.

2. How Forests influence Climate

Did you ever walk along a hot, dusty, sunny road in the summer? Were you not thankful when you came to a tree? You stopped to rest and cool off. Watch a group of cows in a pasture on a hot day. Where do they go to rest and chew their cud? Why?

Shade means cooler temperature. In the summer the hot rays of the sun are kept out of the forest because the trees are so thick and close together. Moisture then remains in the spongy soil.

The evaporation of water from the leaves of the trees also helps to keep the forest cool. It is said that a large oak tree may lose about one hundred gallons of water a day through its leaves. Isn't that a lot of water? Did you ever try to drink one quart of water in a day? Then think of trying to drink four quarts or one gallon in a day. If you drank just one quart of water a day, how long would it take you to drink the number of quarts the oak tree loses through its leaves in one day?

The water that evaporates into the air through the leaves of the trees traveled a long distance before it reached the leaves. It went up through the roots, through the trunk and the branches, into and out of the leaves. The water that passes off through the leaves helps to keep the air cool. The air in and around a forest is usually moist and cool.

When the weather is cool, campers prefer to sleep in the forest. The trees protect them from the chilly winds of the open country. Then, too, the temperature of the forest doesn't change quickly.

Campers also like to sleep in the forest when the weather is warm. Then the air in the woods is cooler, and its temperature is less changeable than that of the air in the open fields. Great forests often protect the country near them from early frosts.

United States Forest Service

These trees were planted near the house to break the force of the wind. What kind of trees are they?

3. Trees as a Windbreak

You have read that winds play an important part in the story of the earth. Sometimes they do good. Sometimes they do harm.

Did you ever watch the wind tossing the branches and leaves of the trees about? Did you ever hear it singing and sighing through the tree tops? Some people love the sound.

When bad windstorms occur, the trees are often a great help. They break the force of the wind and so protect the country near them. We say

that they act as windbreaks. People who live in regions where there have always been trees seldom think how important the trees are. They have always had them; so they think very little about them. People who went to live on the prairies and other treeless plains soon learned how necessary it was to have trees; so they planted them. Fruit-growers in parts of southern California often plant tall trees around their orange groves. Do you know why? They protect the groves from the cold winds that often sweep down from the mountains. They protect them, too, from the hot and dry winds that blow from the desert.

Many farmers plant rows of trees around their fields and buildings. These trees break the force of the wind and protect the fields and farm buildings.

Have you ever seen a windbreak? It is made of one or several rows of trees. The length of the rows depends upon the amount of protection that is needed.

4. Forests prevent Soil from Slipping Away

Where should you find much of the soil that was once on the hillside in the following picture? Why?

What would have prevented the soil from washing downhill?

This picture shows what will happen when a hillside has no trees nor grass on it. Notice the deep gullies, or valleys, made by the water

The trees on this hillside were cut down and destroyed. There were no roots and no soft, spongy humus to hold the soil and water in place. So when the heavy rains came, the water flowed off at once and washed the soil down to the bottom of the hill. The wearing away by water of pebbles, rocks, and soil is called erosion.

Do you remember ever having seen little streams of water running down the slope of a hill after a rainstorm? The streams may leave deep gullies, or valleys. They tear away the stones and soil and carry them to the bottom of the slope. This

is the work of erosion. Some of our rivers have cut deep, deep valleys, called canyons. Can you name any rivers that have done this?

Have you ever seen men building a new road or a state highway? Such roads often go through hilly country. Coarse grass and grain are sometimes planted along the bare, hilly sides of the road. They prevent the bank from going to pieces and slipping down on the roadway.

The roots of trees, grass, and other plants help to hold the small particles, or bits, of soil together and prevent its slipping away. Forests are very important in preventing the work of erosion.

In some of the countries of Europe soil is now carried to the bare mountain sides in bags on the backs of donkeys and people. Then trees and other plants are put in to keep the soil in place.

5. Forests store up Moisture

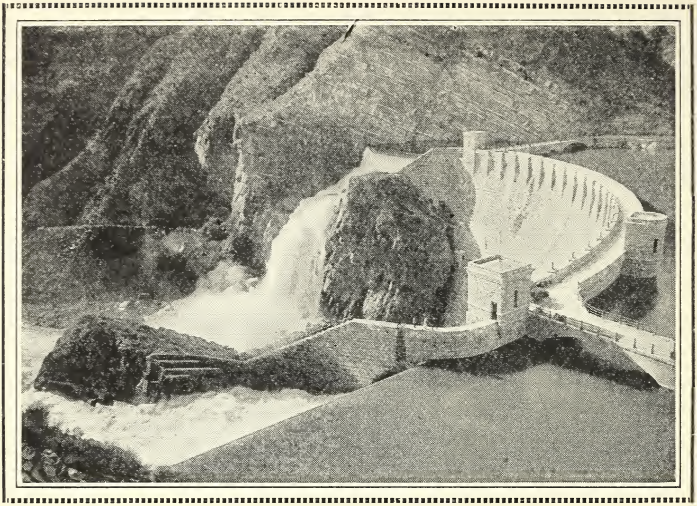
How do the trees store up moisture?

You have learned that the forest floor is often covered with small trees, bushes, and other plants. Leaves of plants drop to the floor and decay. They help to make the rich, black soil called humus. The humus keeps the forest floor soft, loose, and spongy, so that it soaks up the moisture from the rains and the snows.

A flood in a river. What may have caused this flood? What damage has the water done?

Some of the water which this spongy soil absorbs goes into the ground very, very slowly. It may appear later as a cool, clear spring. Many of these little springs form the rivers which begin in the forest. These rivers seldom have bad floods. Neither do they dry up in summer.

Perhaps you live near a stream of clear, cool water. It flows steadily on, year in and year out. Did you ever think that it was probably born away off on some forest-covered mountain? Very likely you never thought that the trees help to keep our streams supplied with water.



The Roosevelt Dam, in Arizona, is one of our largest dams. Find the places where the water is flowing over the sides

When forests are destroyed, the soil usually washes away. The soft, spongy humus disappears. There are no tree roots and nothing to absorb the moisture; so the water passes off quickly and causes floods in the streams. Many floods do a great deal of damage. Villages, towns, crops, and all kinds of living things are frequently destroyed. When the rains are over, the flooded streams become small and shallow and sometimes dry up.

Cutting away the forests is often the cause of great floods and droughts. Can you name a river that causes much damage because of its floods?

Do you know where the water you drink and use in your home comes from? If you live in a city, you no doubt turn a faucet, and the water flows from it. Have you ever thought that this water is carried through miles and miles of pipes to your home? If you live in the country, your water may come from a spring or a well. Some country people store the water from rains and snows in cisterns for future use.

The water supply of many of the largest cities comes from forest streams in the mountains, and these streams may almost always be depended upon to supply water.

In certain places the water from forest streams has been stored. It is often used to turn deserts into vegetable and flower gardens and fruit orchards. Do you know any place where this has been done? Large reservoirs are used for storing the water.

There is a picture of the Roosevelt Dam on page 294. This dam helps to make one of the largest reservoirs in our country.

Look on the map of the United States and see if you can find the Roosevelt Dam. It is in the state of Arizona. How many states may receive water from this reservoir?

Can you name other large reservoirs?

Things to Remember

1. Forests help to bind the particles of soil together and hold it in place.

2. Forests help to control the amount of water the streams receive.

3. Cutting down forests often causes floods which destroy all kinds of living things, cities, and villages.

4. Forest streams may be depended upon to supply water for many purposes.

5. The soil of the forest floor is called humus. It is rich, black, and spongy.

6. Forests are the homes of many birds and other wild animals.

7. Forests help to make a country beautiful.

Problem 2 · Caring for our Trees

1. How to take Care of the Forests

Should you be interested in making a list of all the things you know that are made out of wood? It's fun to see how long a list you can get.

Then make a list of the ways in which you personally have used wood. List the games you have played in which you have used wood in some way or other.

If you make careful lists you will find that wood has a very important place in our homes and in our lives.

It is said that we are using much more wood today than our forests produce each year. This could be done in the past, for trees were used that were growing long before the white man came to this country.

The early settlers in our country traveled westward over hills, mountains, and plains. There were no homes into which they could move. They had to build them. To get wood for their cabins, they cut down the trees. To grow food, they cleared the land of trees for their gardens and farms. Often they cut down a great many trees for their farms. They made the tree trunks into piles and burned them.

Years ago there were many, many trees in our country. Some people act as though there were still a great many trees. Most of the early trees have gone. The people living today should be allowed to use all the wood that they really need, but they should not be allowed to waste it.

What will happen if we continue to use more wood than our forests produce? We should plan to take care of the trees so that the people who live after us may have forests.

There is a subject which tells us how to take care of the trees. It is taught in special schools. It is called forestry.

Here are some of the things that forestry teaches:

1. New trees should be planted when the old trees have been cut out.

2. A certain number of trees should be cut down in order that other trees may grow. Thinning out the trees is as important as weeding a garden.

3. The young trees should be protected while the older ones are being cut.

4. Much wood is wasted by careless cutting; so cut only the number of trees needed.

5. One should watch for insect pests and diseases among the trees.

6. Insect pests should be destroyed.

7. One should watch for forest fires.

8. There are ways of fighting fires.

2. Our National Forests

The United States has put aside for special protection many large stretches of forests in different parts of the country. These forests are taken care of by the United States Forest Service. Men trained in the special forestry schools do the work. At the head there is usually an officer or supervisor called a chief forester. He has forest assistants, rangers, fire guards, and lookout men to help him. The supervisor directs the work of protecting the forests under his care. The main office is in Washington, D.C.

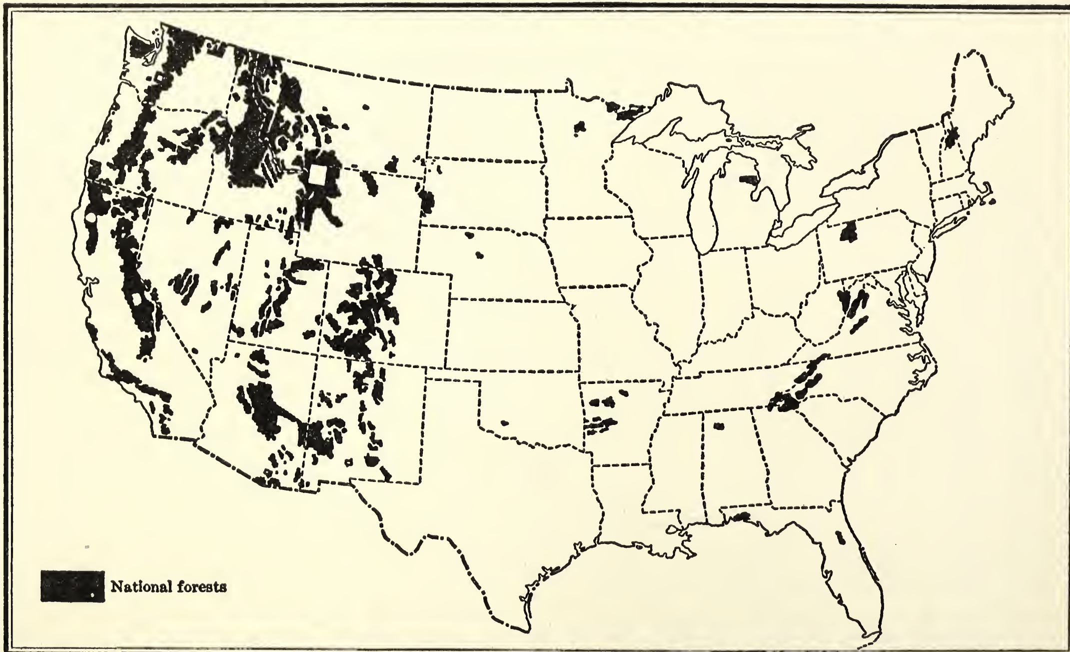
On page 300 there is a map of the United States showing the national forests.

Why do you think there is a greater number of forests west of the Mississippi?

Have you ever seen or visited any of the national forests? Many of them are very beautiful and are called parks. You may be able to name some of them.

Some forests are owned by individual people. They may do as they please with their trees.

There are many reasons why the United States puts aside, or reserves, forest lands. We must have enough lumber. We must have a supply of water for our homes and for our lands. We must try to prevent great floods.



United States Forest Service

The black places show where our national forests are located

Forest rangers on the lookout for fires

The forests need to be protected most against fires and the careless, wasteful cutting of timber.

3. Forest Fires

A forest fire is a most terrifying thing to see. The blaze may start in one part of the forest and in a few minutes spread out in all directions, because of the wind. Millions of dollars' worth of lumber may be destroyed within a short time.

Some forest fires burn for many days. Villages and towns in the path of the fire are often destroyed. Sometimes there is a great loss of life.

There is a great loss of large, beautiful trees too. It takes a long, long time for a tree to grow big.

It is said that almost as many forest trees have been destroyed by fire as have been cut for lumber. The fire also destroys the soft, moist, spongy humus on the forest floor. This makes it difficult for new trees to take root and grow.

The forest ranger must always be on the lookout for fires. His days are spent in watching, watching. Lookout towers are built on the highest points of the forest. Airplanes are also used for this work.

Forest fires are caused in many ways. Sparks from the locomotives of trains passing through forest regions often start a blaze. In some mountain places locomotives now burn oil instead of coal. How will this help to prevent fires?

Many of the fires are caused by carelessness. People sometimes clear their land of rubbish by burning it. If they are not watchful, the fire spreads and reaches the woods.

Campers, picnickers, and hunters start a great many forest fires. They are not careful to select the right kind of spot for their fires. Often the fires which they make run along under the surface and smolder for days. Finally fire breaks out again in a different place, long after the campers have gone.

A forest fire. Bare trunks of trees are left standing after the fire goes out

Lighted matches, cigarettes, and cigars are frequently tossed carelessly away in the forest. They may cause fires, too.

Sometimes fires are started by lightning.

It is very dangerous and difficult to fight a forest fire. Men are often suffocated by the great heat and the smoke. Sometimes the fire-fighters have to work both night and day.

4. Other Enemies of Trees

Many trees in the forest, and in the open country too, are injured or destroyed by storms.

You have seen trees after sleet storms and snowstorms. How beautiful they were! Ice formed on every little twig and branch. The trees looked like fairyland. But the twigs and branches were small. The ice was heavy. Many of the twigs could not stand the weight of the ice and broke off. The trunks of young trees often break in this way, too. During snowstorms the branches of evergreen trees become heavy with their coverings of snow. They look very lovely, but frequently they break off and spoil the trees.

Wind often uproots trees. Some trees do not send their roots deep, deep down into the ground. The crowns, or tops, of the trees are often very thick and heavy. When a bad windstorm comes, the trees blow down. It often happens that a tree is diseased and weak and cannot stand during a strong windstorm.

These trees are lovely, with their covering of snow. What may happen when the branches are so weighted with snow?

Trees often protect one another during windstorms when they stand close together. This prevents many of them from blowing over and having their branches broken off.

Insects are frequently at work searching for food. Sometimes hundreds of them may feed on the leaves of trees and eat most of them. When the leaves are destroyed, the trees cannot make their food. If this should happen year after year the trees would die of starvation.

Certain insects live under the bark of trees. They feed on the growing layer of the tree. These insects work without being seen. They often destroy even the solid wood of the tree. Such trees become weak and frequently blow down during windstorms.

Animals, such as sheep and cows, that like to eat tender green shoots and twigs may prevent the growth of new forests. When they are allowed to graze in woodlands, they eat the young, tender seedlings.

Rodents, or gnawing animals, do their share of damage, too. They eat a ring of the bark and wood all around the trunk of the tree. Then the tree can't get its food, and it dies. Some countries offer rewards for killing rodents that have become pests. What rodent animals do you know?

Have you ever seen horses tied to trees?

United States Forest Service

These cows may eat the young, tender seedlings in this forest. Are these trees evergreens or deciduous?

Why isn't this a good thing to do?

How should trees be protected when horses are tied to them?

You have learned that fungi are plants that cannot make their own food. They have no green coloring matter, or chlorophyll; so when fungi attack trees they eat the food which the trees prepare. Some fungi form shelflike growths on the

outside bark of trees. The appearance of these shelflike parts shows that the tree is diseased and weak. The spores of the fungi often enter the trees through wounds made in the trees. These wounds should be taken care of so that the tree may go on living.

Many trees die every year because of fungi. Chestnut trees have almost entirely disappeared in some parts of the country because of a fungus which causes a disease of the bark. A remedy for the pest has not yet been found.

Trees have a great many enemies which, if they are given a chance, may destroy the forests. Still, with intelligent care, enough trees may always be grown to supply us with wood, to hold the soil in place, to prevent bad floods, and to keep water in our streams.

Many poets have written poems about trees. You might like to see how many of these poems you can find. Put in a scrapbook the ones you find.

Things to Remember

1. Never give some fungus pest an easy entrance into a tree by carelessly breaking off its branches.

2. Always cut branches close to the main stem. Bark may then grow over the wound.

3. If a wound is covered with coal tar or paint, fungi may not enter.

4. Camp fires cause many forest fires.

5. Select a sandy or gravelly spot for your fire.

6. Never build a fire where there is a layer of evergreen needles or against a fallen log.

7. Never go away and leave your camp fire burning. A fire is never out until the last spark is gone.

8. Never throw lighted matches or cigarettes on the forest floor.

Things to Do

1. Make posters or signs about preventing forest fires.

2. Make posters or signs about preventing wasteful cutting of branches and young trees.

3. Make posters or signs about preventing the breaking of branches of trees that have beautiful flowers, ripened berries, or (in the autumn) colored leaves on them (dogwood, black alder, pussy willow).

4. See how many different forest trees you can call by name.

5. Try to know the names of the trees near your home.

UNIT XI

Animals that Change their Appearance

1. Toad, Frog, and Salamander
2. The Butterfly and Other Insects

ANIMALS THAT CHANGE THEIR APPEARANCE

It has been said that a toad in a garden is worth its weight in gold to the owner of the garden. Why should this be true? Read the following problem and see if you agree with the person who said this.

Many unusual things happen in the lives of the toad, the frog, and the salamander as they grow up. As you read the next problem you will find out what these unusual happenings are.

Caterpillars may be found almost everywhere. Do you know what they may become if they are allowed to live and grow?

Some caterpillars cause a lot of damage and are great pests. Others are not pests at all. In Problem 2 the life story of the butterfly is given. In this problem you will also find the names of some caterpillars and moths that are considered great pests.

Problem 1 · Toad, Frog, and Salamander

1. Growing Up

Dogs are little dogs, or puppies, when they are young. Cats are little cats, or kittens. When they are young, men and women are baby boys and baby girls. The young of all mammals look very much like their parents in almost every way, except that they are smaller. This is true of reptiles too. Snakes are little snakes, and turtles are little turtles, when they are born. Baby alligators and baby lizards are also like their parents.

But this is not true of all kinds of animals. The young of some do not look at all like their mothers and fathers. Some of them are so different from their parents that one would never know they belonged to them.

You have seen many toads and frogs and butterflies. The young toad and young frog are not the least bit like their mothers and fathers. And who would ever think that the crawling caterpillar is the young of some beautiful butterfly or moth?

This problem will tell you how the young of these animals grow up to look like their parents. You will find that many unusual things happen in the early lives of these animals.

2. The Toad

The toad is born in a pond. It lives there while it is a tadpole. Then it grows legs and hops onto the land. It hops and hops until it comes to a garden or the woods. Then it rests and eats. When autumn comes, its food grows scarce. So under the leaves, deep into the ground, it burrows and goes to sleep. Its body grows colder and colder in its underground nest. When the very coldest winter days come, the toad's body is so numb that it does not even feel the cold.

Then the warm spring days arrive, and the toad wakes up. It leaves its cozy nest under the ground. It splits its old skin, tears it off, eats it, and then hops back to the pond.

Why does the toad go back to the pond?

At the pond the toad finds its mate. The male toad usually arrives there first, and he sings and sings. Sometimes he sings all day and all night. Then the female comes to lay her eggs. After the eggs are laid, the male covers them with a liquid which makes them grow later into tadpoles.

The mother toad's eggs are very small and black in color. She usually lays them in a single row in a clear, jellylike substance. Sometimes she drops them on the bottom of the pond. Sometimes she fastens them to plants that grow in the water.

Toads' eggs and tadpoles in the pond. Do you know how toads' eggs differ from frogs' eggs?

Then she swims away and leaves them. She may never see the eggs or the young again. Doesn't it seem strange for a mother to go away and leave her young to take care of themselves? It would be impossible for the mother toad to care for her young because there are so very many of them. They get along very well without their mother.

In a few days the eggs hatch. The tiny tadpoles wriggle their way out of their jellylike covering and swim about in the water. They look and act like little fish. One would never think they were young toads.

In order that they may live in the water like fish, the little tadpoles must be able to breathe

like fish. On each side of their necks there are little bunchy growths that look like fringes. These are the gills, through which they breathe.

After a few days the tadpoles lose these gills and breathe through gills which are just inside a little opening. This opening is a breathing pore. As the tadpole grows bigger, it pushes its left arm out through this breathing pore. The right arm grows inside and then breaks through the skin when it is ready to come out.

The tadpole is hungry, just like any other baby in the world. It feeds on the tiniest kinds of green plants that it finds in the water. Sometimes it may feed on the tiniest kinds of animals too. These little plants and animals are found in the slime on the surface of the water, at the bottom of a pond, or around the larger plants in the pond.

Even though the tadpoles look and act like fish, changes are being made on the inside and the outside of their bodies. For a time they seem to be nothing but heads and tails. Then the hind legs bud and begin to grow. Soon they are large and strong enough to be used in swimming.

After the front legs, or arms, appear, the tadpoles no longer look like fish. Their small mouths have become very large. Their eyes have grown big and seem to stand way out on their heads. And their tails grow shorter and shorter until there

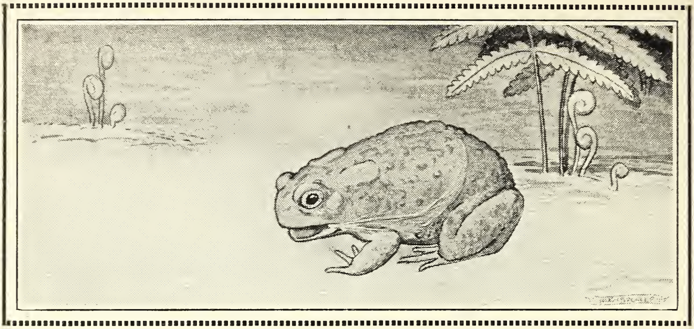
are no tails at all. Of course now the tadpoles act differently, too. They come up to the surface of the water and stick their heads out for air. They no longer breathe through gills, like fish, because lungs have formed inside their bodies. They must come up out of the water to breathe or they would drown. Sometimes they spend most of their time near the surface of the water.

As soon as the tails have disappeared, the wiggling tadpoles, or polliwogs, have changed to toads. They are smooth and small.

3. The Toad on Land

Sometimes a great many little toads hop out of the pond at the same time. If they leave the water on a rainy day, they hop off in every direction. Because so many of them are found hopping about after a gentle rain, some people say that they are rained down. But it only means that the toads like the moisture.

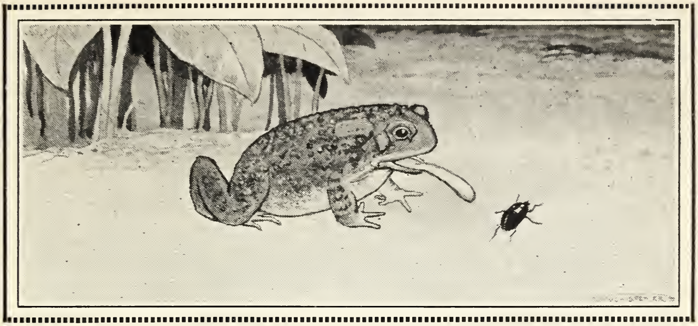
The toads soon lose their smooth skin. Their coats often become warty and rough before they are a year old. Neither do they always remain little toads. They grow bigger and bigger very rapidly. To do this they molt, or shed their outside skins, every four or five weeks. Even the older toads molt three or four times a year.



This toad is shedding his skin. Look at the corner of his mouth. What do you think will soon happen?

It is great fun to see a toad shed his skin. He does it so quickly! He can really shed his whole skin in about five minutes. When he is ready to molt, he humps his back, bends his head downward, and pulls his feet under him. The loosened skin splits down the middle of the back and down the middle of the under part of the body. He opens and shuts his mouth many times. Then he begins to draw the old skin into the corners of his mouth. Sometimes he uses his front feet to help him get the skin away from his eyes. Then what do you think? He swallows his old skin!

Toads feed on all kinds of small living things that wander about at night or in the late afternoon. They are of very great value to people who have greenhouses. They are great friends of the farmer and the gardener, for they eat the harmful



What is this toad going to do? His tongue seems very long. Do you know why?

insects that destroy their crops. In some countries gardeners even buy toads to put in their gardens. Sometimes a toad will sit for hours catching flies and mosquitoes that come near him. He seems to be always hungry; so he hunts and hunts in order to get the amount of food he needs.

The toad's tongue is not like the tongues of other animals. It is sticky, and it is fastened to the front part of the lower lip. This makes it possible for him to throw his tongue far out of his mouth when he is catching his food. He has no teeth; so he swallows his food whole. It has been said that a toad will eat about ninety-nine hundred harmful insects in three months.

Has someone told you that if you handled a toad you would have warts? This is just a silly story. The toad's body is dry and cold when you

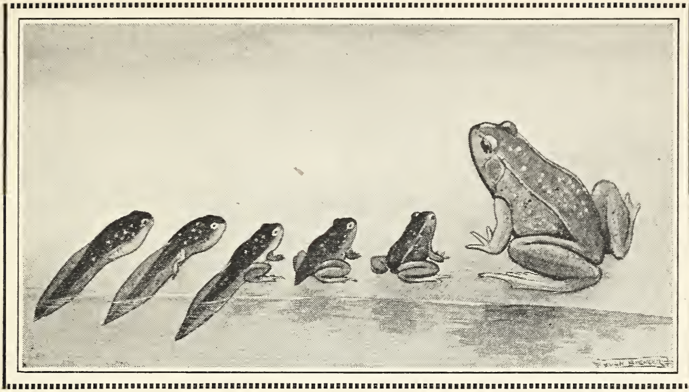
touch it. The warty-looking lumps on the skin are glands. When a toad is disturbed or in danger, a very disagreeable, sticky substance is thrown out of these glands. This is one way the toad has of protecting himself.

Toads have a great many enemies. Many kinds of snakes, crows, hawks, and owls feed upon them. Even ducks and chickens will eat them. Hungry young snakes are the worst enemies the small toads have.

The toad has a habit of "playing dead" when he is frightened. He lies on his back and doesn't move for a long time. He doesn't seem even to breathe. Then suddenly one leg is lifted, then another, his eyes open, and he tumbles over and hops away. This trick has saved the lives of many toads. Animals that feed only on living things often go away and leave him when he is playing dead. Many toads look so much like the ground that their enemies do not see them. The toad's habit of burrowing under a stone or a board or in the soft earth also protects him.

It is thought that toads live to be fairly old. A story is told of one that lived for thirty-six years; then it was accidentally killed.

Toads belong to a class of animals that is known as Amphibia. The members of this class have two different kinds of lives. They begin life in the



Tadpole growing up. Notice the changes the tadpole makes in growing up to be a frog

water, where they look and act like fish. After a while they change and are no longer like fish, and live on the land. But not all animals that live both in the water and on the land are amphibians.

No doubt you have heard of amphibian airplanes. Do you know why they are called amphibians? It is because they have boats for landing on the water and wheels for the land.

4. Toads and Frogs are Alike in Many Ways

The life stories of the toad and the frog are very much the same. Both are born in the water. In early spring the eggs are laid in jellylike strings or masses on the bottom of ponds or among the water plants.

The tadpoles of the frog need a longer time in which to grow up than the tadpoles of the toad.

Both have long, powerful hind legs. These legs help them in jumping, leaping, and swimming. The front legs are short and weak. They are used to keep the front part of the body away from the ground.

The skin of the frog is smooth, moist, slimy, and slippery. The glands give out a substance which keeps the skin moist. The skin of the toad is dry and rough.

Many frogs stay in or about the water most of the time. If they are disturbed when they are on land, they hasten to get back to the pond. They take long leaps and splash into the water. Toads stay mostly on the land.

Since it spends so much of its time among the grasses and bushes at the water's edge, the frog's color is likely to be brown and green. Many frogs seem able to change their color with their surroundings.

During the long winter months frogs, as well as toads, hibernate. Frogs go into the mud in or near a pond. They usually burrow deep enough in the mud to escape freezing. Toads burrow into the ground, too.

When the frog is on land, it also feeds on insects. Two groups of teeth on the roof of its

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These frogs are resting on a stone. Notice the width of their mouths

mouth prevent the insect from getting away after it has been caught. The toad has no teeth.

The bodies of the frog and the toad have two parts, head and trunk. There is no neck. The head is triangular in shape and is as broad as it is long. An odd-looking eye sticks out from each side of the head. The two nostrils are at the end of the snout.

5. The Tree Frog

At the end of winter have you ever listened rather longingly for the song of the first robin, the first bluebird, or the first sparrow? Why were

you anxious to hear their songs? Was it because they told you "Spring is here"? A few stormy, wintry days might come, but you knew spring was not far away.

You may have heard other tiny animals add their voices to tell the good news, too. You do not often see these little singers. Their colors hide and protect them. They are the little tree frogs. You know them only by their song. Sometimes people call them toads and "peepers."

The adult tree frog usually spends its life in shrubs, bushes, and trees. There it trills its little song during the warm summer days. It climbs about easily, because on its toes and fingers there are queer little pads. These pads help it to cling to things.

Like toads and frogs, these little creatures are born in the ponds in the spring. The tadpoles are the tiniest little fellows! They often come out of the water while their tails are still long. They feed on ants, gnats, and mosquitoes; so they are helpful little animals.

In the winter they go to sleep under the mosses and leaves.

Tree frogs would be interesting to keep in your aquarium. You may have difficulty in getting them. In the spring, search for them at night around the banks of ponds.

Experiment with them. See whether their color changes when you place them on cloth or paper of different colors.

6. Salamanders

Joan and Ned were very much interested in salamanders. They had read a great deal about them in their books. One of the things they learned was that these tiny animals loved shady paths and woods, particularly after a rainstorm.

"Come on, Ned," said Joan one rainy day. "This is just the kind of day to find salamanders for our aquarium."

"All right," said Ned; "let's put on our raincoats and rubbers. Then we'll be dressed for the rain."

Taking a tin box with them, they started off. They walked slowly along the road that led to the woods. It was bordered on both sides by trees and was quite wet because of the rain. On and on they went.

Suddenly Ned exclaimed: "Look, look, Joan! There's one."

"And there's another, and another!" cried Joan, excitedly.

"Do you wonder that some people tell you they are rained down?" asked Joan. "There are so many of them!"

Joan and Ned take a walk in the rain
to find salamanders for their aquarium

"Do you think anyone really believes that?" asked Ned.

"Yes, I think some people do, but we know they are out in large numbers because the road is damp and shady," replied Joan.

"Just think, Ned. They usually wait until the ground is damp or wet before they do very much traveling about to hunt their food. Sometimes they must get quite hungry."

"How many shall we take for our aquarium?" asked Ned.

"Not more than two. That's enough for us to watch and study," said Joan. "Remember, Ned, they eat aphids, or plant lice; so they help the plants."

"They eat some small earthworms too," said Ned. "And earthworms are good for the soil."

"Let's go home now and fix our aquarium," said Joan.

Here are some of the things that Joan and Ned learned about salamanders:

1. Some salamanders lay their eggs among the weeds in fresh-water ponds.

2. The eggs have tough outside coverings which protect them until the young are hatched.

3. Changes occur in the bodies of salamanders. While they are in the water they are like small fish. They breathe through gills.

4. They usually remain on land about two and a half

years. Then, once again, they go to the water. They often travel over long distances to reach a pond or stream.

5. In order that salamanders may return again to the water, certain changes must occur in their bodies. By some means they again become able to breathe the air which is in the water. Their color may change, but the spots along their backs remain the same. In the water the salamanders find their mates.

6. Sometimes salamanders are wrongly called lizards. Lizards have scaly skins. Salamanders have not. Newts are very much like salamanders. Salamanders are amphibians, while lizards are reptiles.

Things to Think About

1. How a toad is like a frog.
2. How a toad is unlike a frog.
3. Why a toad is valuable to man.
4. What the word *Amphibia* means.

Problem 2 · The Butterfly and Other Insects

1. Caterpillars

The brightly colored butterfly that flits from flower to flower begins its life as a caterpillar. You may find it difficult to believe this, but it is true. When you see a caterpillar crawling on the ground or among the leaves hunting for its food, there is really nothing about it to tell you that some day it may be able to fly. It doesn't look a bit like a butterfly.

Every caterpillar doesn't change into a butterfly. Many of them become large moths.

Moths and butterflies look somewhat alike. Nearly all moths fly about at night and often are attracted by lights. Their bodies are heavier than the bodies of the butterflies. When they are resting they hold their wings close to their bodies or spread out flat. When butterflies are at rest they hold their wings close together in an upright position. They fly about in the daytime.

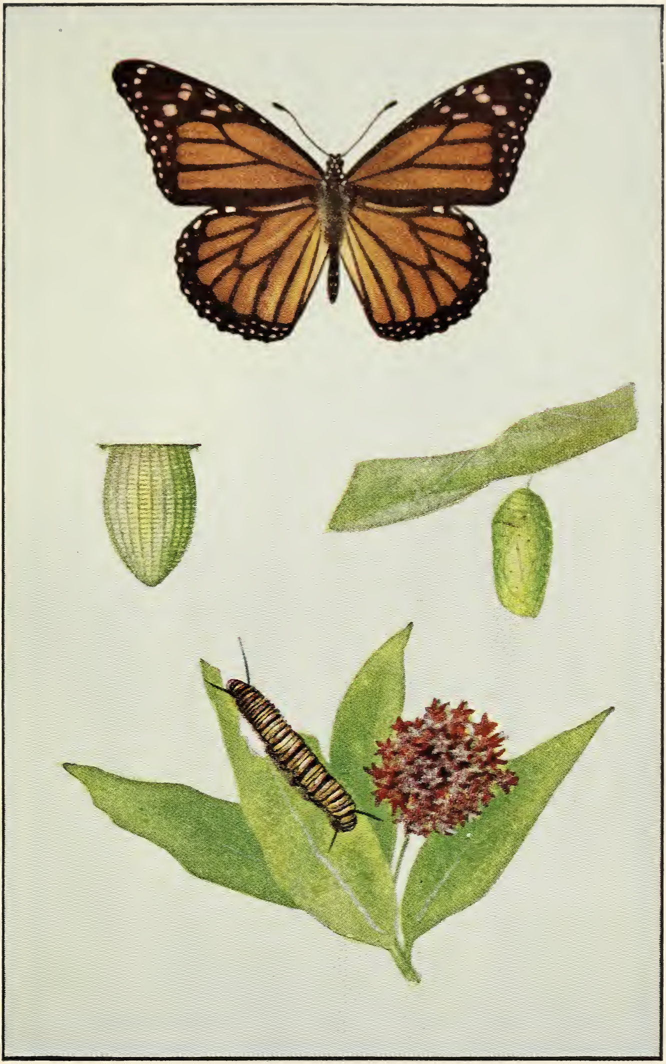
You have learned how tadpoles change into toads, frogs, and salamanders. You may even have seen them make the change. When a caterpillar becomes a butterfly or a moth, it hides itself inside a thin skin, or covering, and rests while its wings are growing and its body is changing.

A toad changes its form three times in growing up. It is an egg. It is a tadpole, or larva. It is a toad. But a butterfly or a moth changes its form four times. It is an egg. It is a caterpillar, or larva. It is a pupa, or chrysalis. And then it is the butterfly or the moth. The pupa, or chrysalis, is the quiet stage in the insect's life. The caterpillars of some moths spin a silken cocoon with which to cover the pupa, or chrysalis. The caterpillars of butterflies do not do this.

Naturalists have a word for the way toads and butterflies change their looks in growing up. They call it metamorphosis.

The mother butterfly lays her eggs on the young, tender leaves of a plant. She usually selects the kind of leaf that the little caterpillars like and will begin to eat as soon as they are hatched. There are some butterflies that do not see very well, but their sense of smell is so keen that it always guides them to the right plant. Some eggs are laid singly. Some are laid in clusters. Others are laid in masses. The mother butterfly takes no care of her young. After her eggs are laid she flies away.

In a few days the eggs hatch. Some young caterpillars first eat the shells of the eggs. Then they begin to feed on the leaves of the plant. Their bodies are long and slender and are covered



A monarch butterfly grows up. Can you find the egg, the larva, the pupa (or chrysalis), and the butterfly? The egg is magnified many times

by a thin skin. Some caterpillars are green in color. Some are brown. Others are gay in their coloring. All of them have three pairs of legs near the head. These are called the forelegs, and they are like the legs which the butterfly has. Most caterpillars have five other pairs of legs. They disappear when the insect becomes a butterfly or a moth.

A caterpillar is usually very hungry. Its jaws are powerful and well fitted for cutting and chewing. It eats and eats until it cannot eat another mouthful. Its skin becomes too small; so it rests and gets ready to molt. The skin splits down the middle, and the caterpillar crawls out. It has grown bigger. Soon it is hungry and begins to eat again. It may shed its skin in this way four or five times. Then it is as big as it ever will be; so it turns into a pupa, or chrysalis.

As a pupa the caterpillar doesn't eat. It doesn't crawl about. It doesn't do anything but rest and wait while its body changes and its wings grow.

Different caterpillars get ready for their pupa stage in different ways. Some of them spin tiny silk mats on the underside of a leaf, on a twig, or in some sheltered spot. They fasten themselves to these silk mats and hang quietly while their bodies change and their wings grow. Some of them bur-

row into the ground and make little caves. Here they stay during their pupa stage. Others spin yards and yards of silk, which they make into coverings, or cocoons. In these cocoons the pupæ are protected while the bodies are changing.

All caterpillars do not remain in the pupa stage the same length of time. Some may change to butterflies in a couple of weeks. Some need a longer time. Most caterpillars that turn into moths usually remain in the pupa stage in their cocoons or in their underground caves during the winter. Some butterflies lay eggs two or three times in one year.

When the butterfly is ready to come out, the skin, or covering, of the chrysalis opens. The opening grows wider and wider until the whole body of the insect is out. As soon as the feet appear they find a place on the old chrysalis skin. Here the butterfly hangs and rests. It seems quite helpless. Its wings are soft and moist and are folded close to the body. But the time soon comes when the moist wings are dry and strong, and away the butterfly flies into the air and sunshine.

The caterpillars that turn into some kinds of moths must break their way through a cocoon. Some of our largest and most beautiful moths, the *Cecropia*, the *Luna*, and the *Polyphemus*, must do this.

2. Some Caterpillars cause Much Damage

Butterflies and moths do not eat the leaves of plants. They no longer have cutting and chewing mouths. Their feeding is done when they are in the caterpillar, or larva, stage. Then they eat most of the time. The full-grown insect flies from flower to flower to get the sweet nectar, but it takes no other food.

The caterpillars of some butterflies and moths destroy many, many dollars' worth of crops and trees every year. Some of them are social in their habits. When they occur in very great numbers they need a lot of food. They may eat most of the leaves of the plants and the trees; then they become pests. The army worm, the tent caterpillar, and the caterpillars of the gypsy moth and the white-marked tussock moth are among the worst pests we have.

It often happens that plants have too many leaves. Sometimes plants grow too close together. The number of leaves and the number of plants need to be thinned out. Thinning out some of the plants and leaves helps others to get the light and grow strong and healthy. By eating some of the leaves, the caterpillars often help the plants.

Most caterpillars are not social in their habits. They seem to be solitary and live alone. Some

boys and girls call them worms. They are not worms. The true worms do not have legs. The earthworm, often called the angleworm, is a true worm, and it has no legs. The caterpillar has six jointed legs.

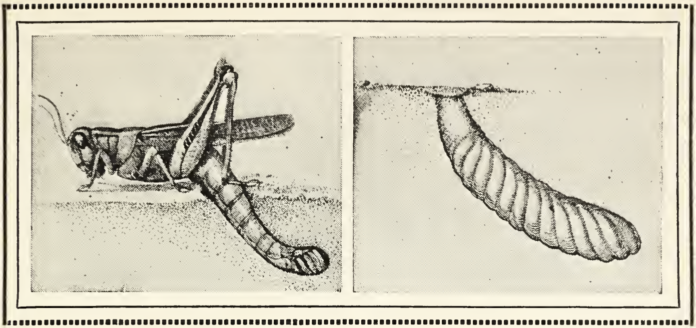
3. Insects that make Some Changes as they Grow Up

Grasshoppers, cicadas, locusts, crickets, cockroaches, dragon flies, and damsel flies are some of the insects which are not caterpillars when they are small.

The larva of some of these insects, when it is hatched from the egg, resembles the full-grown insect. It eats greedily. It splits and sheds its skin when it grows larger. Small wings begin to grow, and increase in size every time the skin is shed. Then the adult insect appears. These insects have *incomplete* metamorphosis. The pupa (the quiet stage) is missing in their lives. Sometimes the young of these insects are called nymphs.

Did you ever walk through a field and scare many young grasshoppers from their hiding places?

They had no wings, but in other ways they looked like their parents. Why were there so many



A mother grasshopper laying eggs in the ground. Notice the egg case

of them? The mother grasshoppers lay hundreds of eggs in the ground in the fall. The young are hatched in the spring. They eat almost any green plant they find. They shed their skins when they increase in size. They never eat their cast-off skins as some of the caterpillars do. Only the full-grown grasshoppers have wings. There is no pupa stage in their lives.

Have you ever found the cast-off shells of the cicadas on the trunks of trees in the summer?

Sometimes the cicada is called the seventeen-year locust. Sometimes it is called the harvest fly. It is a large insect with rather a blunt head. The eyes are large and stick out like frogs' eyes. It has long transparent wings. Surely you have heard its song during the warm days of summer. Wherever there are forests and orchards, all over the world, you will find the cicada too.

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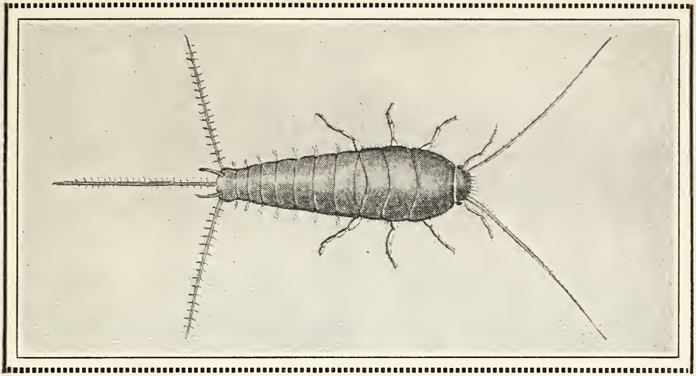
A cicada coming out of its shell. Did you ever find cicada shells on the tree trunks in summer?

One kind of cicada lives in the ground for seventeen years. Then the adult insect comes out. It crawls up the trunk of a tree and sheds its skin. The old skin is left clinging to the bark. The mother cicada looks for the freshest and tenderest twigs on the tree. She bores holes in them in which to lay her eggs. In about six weeks the young cicadas hatch out. They are called nymphs. The nymphs drop from the tree and dig their way into the ground. There they stay, living upon the juices of the roots. They grow and molt until the seventeenth year. Then they come out of the ground.

All other cicadas go through these same stages in passing from the egg to the adult, but they remain in the ground only a short time.

Have you ever seen a flat, silvery, fishlike in-



The silver fish. This insect likes the bindings of books. Have you ever found it among your books?

sect among your books and papers? Sometimes you may have seen it on a papered wall in your home. No doubt it hurried off as soon as it was discovered. It moves very rapidly. This was the silver fish. It does not change its appearance in growing up. It always looks the same. It has no metamorphosis.

Because the silver fish has no metamorphosis (that is, no change of form from egg to adult), it is put in the lowest order of the large insect family. Sometimes these insects do a lot of damage. They destroy the bindings of books, card labels in museums, and clothing that has been starched. Now and then they get into stored foods also; but they seem to prefer the paste that is used in bookbinding and on wall paper.

Things to Do

1. Get a few toads' or frogs' eggs from a pond in the spring. Put them in a bowl of water or an aquarium and see what happens.

a. Do not keep too many tadpoles in one bowl or one aquarium.

b. Do not keep your bowl or aquarium in the sun. The water may become too warm. Then the tadpoles may die.

c. When the tadpoles' tails are growing shorter, put a stone, a stick, or some sort of platform in your aquarium. Be sure that it comes just above the surface of the water. Why?

d. When the adult toad or frog appears it will need live food. When you can no longer care for your toads or frogs indoors, put them outdoors where they can care for themselves.

2. Do you know the monarch butterfly? It is one of the largest butterflies, and it may be found flying about almost everywhere. Its colors are orange and black. It has a double row of white spots on the border of its wings.

a. Look for the eggs or caterpillars of the monarch on the leaves of the common milkweed plant during the summer.

b. If you find them, put some in a glass dish or a jar and carry them home.

c. When the young hatch give them fresh milkweed leaves every day and take good care of them.

d. Watch carefully to see what happens.

If you succeed in finding these caterpillars, you may be able to see how the monarch butterfly changes and grows up.

3. Look on the leaves of parsley and Queen Anne's lace for the eggs or caterpillars of some of the swallowtail butterflies. If you find an early brood of these caterpillars, they may become butterflies in a few weeks.

4. In the autumn, after the leaves have fallen, you may find the big cocoons of some of our loveliest moths. Look for them on the bare twigs and branches. It may be difficult to see them because their color is so much like the color of the branches. If you keep them in a warm room, be sure to sprinkle them with water about once a week; but it is best to keep them in a cool place. It will give you a lot of pleasure, if you do find cocoons, to see the beautiful moths that are in them come out in the spring.

UNIT XII

Insects

1. The Place of Insects in Nature
2. Insects that are Harmful to Man

INSECTS

Do you know that some insects were on the earth long before man? The ant, the cockroach, and the termite are animals which have lived on the earth for thousands and thousands of years. Some people say insects have such wonderful bodies that they may be living on the earth long after man has gone.

Do you know it is thought by some that man must wage war on the insects or be conquered by them? Some say it will be the greatest war we have ever fought. Others say man can only win by using his greatest weapon, that is, his intelligence. What do they mean? How can we fight insects? Does that mean we should kill every insect we meet? Are all the insects harmful?

Some insects enter our homes and eat our food. Some insects eat our clothes. Some eat the paper and glue in our books. Some destroy the grain and cotton in the fields. Some help to spread diseases. Some even make holes in lead. Is it their fault? Do they hate man? Or is it that man likes and needs some of the same things that insects do?

Problem 1 · The Place of Insects in Nature

1. Insects in Nature

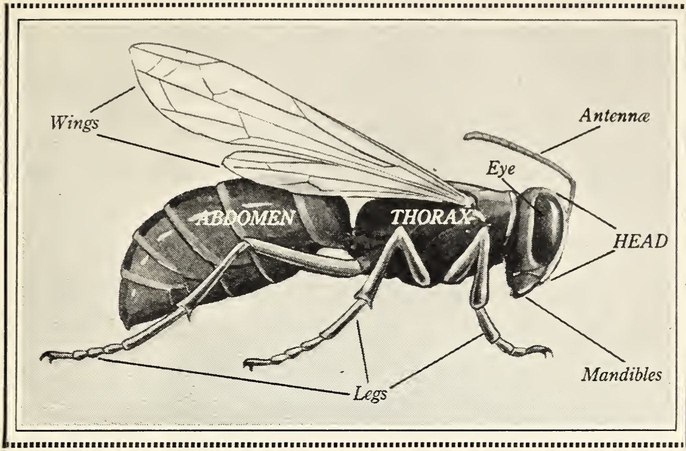
You may be surprised to know that the number of different kinds of insects in the world is very, very large. It is larger than the number of the kinds of all the other animals taken together. If we should count the different kinds of mammals, reptiles, birds, fishes, and all the other living animals, we should have a great number; but this big number would be smaller than the number of the different kinds of insects. It is said that there are about a half-million kinds of them on the earth. Some of these insects are very useful to man. Some of them are quite harmful. Many of them do not help man in any way, but neither do they harm him. We know little or nothing about a great many of them.

Insects can live almost everywhere. They live in deserts. They live in hot countries. They live in cold countries. Even the people who live in the far, far North are annoyed by gnats, midges, and mosquitoes during their short, warm summer. There are insects that live in the air. There are insects that live in the water. There are insects that live on the land. Some of them burrow under the surface of the land.

Did you know that an insect wears its skeleton on the outside of its body? Your hard, bony skeleton is on the inside of your body. Your soft flesh is on the outside. The insect's outside skeleton, or skin, is very firm. It stretches but very little. It is called chitin. The soft parts of the insect are inside this skeleton. When you grow bigger your mother buys or makes new clothes for you. When an insect grows bigger its skin bursts open, and it crawls out of the old skeleton. We then say that the insect has shed its skin, or molted.

If you look carefully at an insect's body, you will see a number of little ringlike parts. These parts are called segments. They are joined together. You will also see that the body is divided into three large parts. One of the parts is the head. Another part is the thorax, or chest. This part is in the middle. The third part is the abdomen. You have a head, chest, and abdomen, too. All insects have their bodies divided into three parts. The legs, six of them, grow out from the thorax, or middle part of the body. Some insects have four wings. Some have only two. The wings are also fastened to the thorax.

Insects do not breathe air as many animals do. They have no lungs, but they do have little openings, or breathing pores, on the sides of their bodies. These pores are connected with tiny tubes



This picture shows you the parts of an insect's body. Look at it and find the names of the different parts

inside the body. The air passes through the breathing pores into these tubes and then into the body.

Insects must have food. Some of them have mouths that are made for chewing young and tender leaves. Some have mouths made for catching their food. Others have sucking tubes, which they use in getting the blood of animals and the juices of plants. Many insects live on food that would cause other animals to die. Some of them eat wood. Some eat feathers. Others eat fur. Even our woolen clothing may be eaten by the larva of a tiny moth.

There are people who think that all insects are bad and should be killed. Of course this is not

true. When we think of the great number of insects in the world, the number of harmful ones is very small. However, man must constantly fight the harmful insects. If he doesn't, his food, his trees, and some of his clothes may be eaten and destroyed. A few of the harmful ones may attack and annoy him. Many animals suffer a great deal when they are bitten or stung by insects. It has been very difficult for man to settle and build his home in parts of the warm tropical countries because of the harmful insects.

On the next pages you will find more about useful and harmful insects.

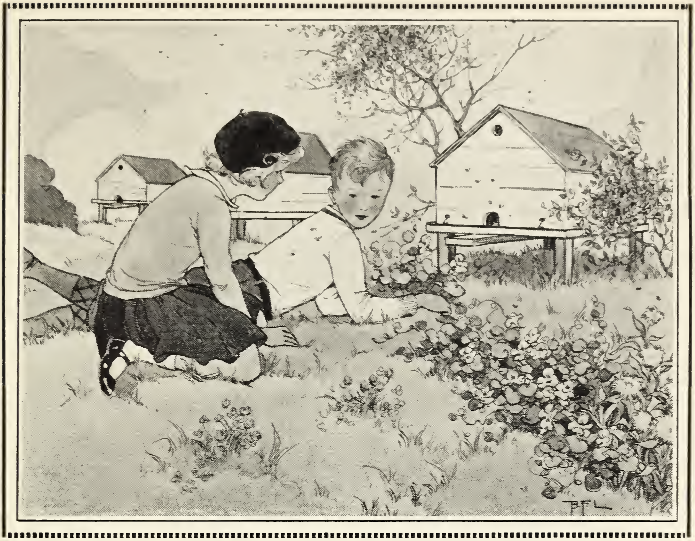
2. Insects that are Useful to Man because of what they Make

The honeybee

For thousands of years honey has been used for food. It was the first sweet food that ancient people knew. Honey is still used in great amounts today.

Plants make nectar in such tiny amounts that man could not afford to gather it. Even the bees work very hard. It is thought that they travel twice the distance around the earth in order to make just one pound of honey.

Honeybees are even more valuable because they carry pollen from flower to flower. In their work



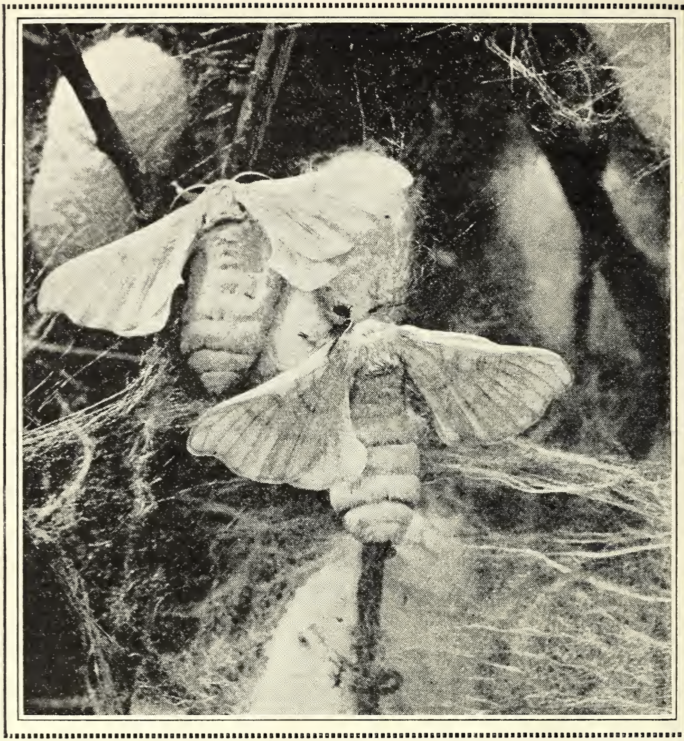
Joan and Ned are watching the bees in the hives on their uncle's farm. Why are they not afraid the bees will sting them?

of gathering nectar, pollen clings to parts of their bodies; and when the next flower is visited, some of the pollen is left.

Bees give us wax too. This wax is of great value to man. It is used in making polishes, varnishes, candles, and ointments. Dentists often use wax in their work on people's teeth.

The silkworm

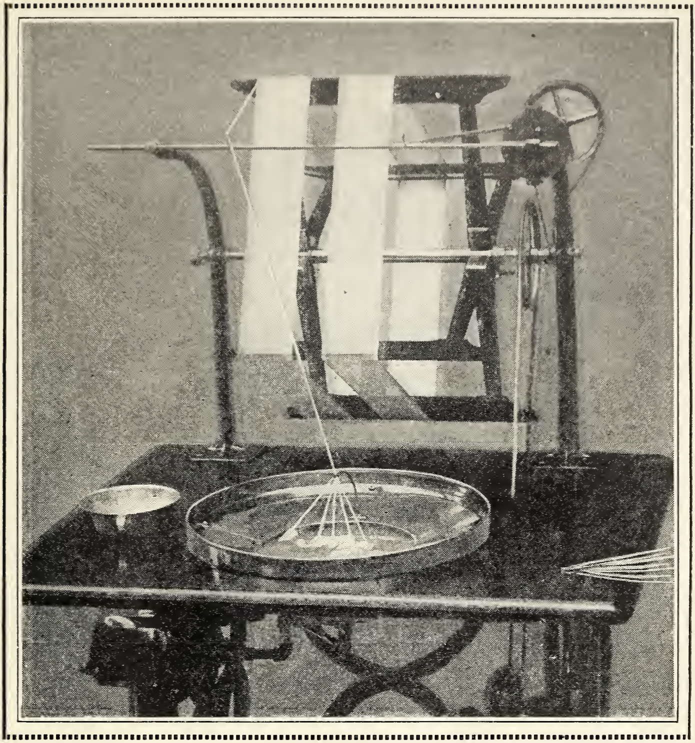
Long, long ago only the very rich people who lived in China could afford to wear clothes made out of silk. The Chinese were then the only people



Cornelia Clarke

Silk moths and their cocoons. Notice the fine silk threads running from twig to twig. Do you think it would be easy or difficult to unwind the silk thread from the cocoon?

who knew about silkworms. They knew how to feed and take care of them. They knew how to get the long silk thread from the cocoons and how to weave this thread into cloth. But the Chinese didn't want anyone else to know how they ob-



© Nonotuck Silk Co.

Unwinding the silk threads from cocoons

tained their silk. It was their secret. And they kept their secret for thousands of years. Then people found out about it in this way.

There were two monks who lived in China for many years. They learned all about the silk-worms, and they found out how to make the silk cloth. When they returned to Europe they hid

some of the tiny silkworm eggs in the hollow parts of their bamboo canes and carried them away with them. This was a very risky thing for them to do. If the Chinese had caught them, they would probably have been put to death. For many years the only silkworms that were raised in Europe and America were descended from the eggs that these monks carried with them.

Silkworms are among our most important domestic animals. We raise them as we raise our cows, our sheep, and our horses. They are never found in a wild state.

The silkworm is not really a worm. It is the caterpillar of a certain kind of moth. The caterpillar feeds on the leaves of the mulberry tree. It spins yards and yards of pure silk thread and uses it in making its cocoon. Man unwinds the thread from the cocoon and uses it for all kinds of silk materials.

Man also makes "artificial silk" today. To make this silk, he uses parts of wood pulp.

The lac insect

Lac insects are very valuable. They are tiny scale insects which grow on trees in India. A liquid comes from their bodies which hardens when the air touches it. This protects them from their enemies. These insects gather close together

Layers of lac on the branches of a tree in India. How is lac made on the branches?

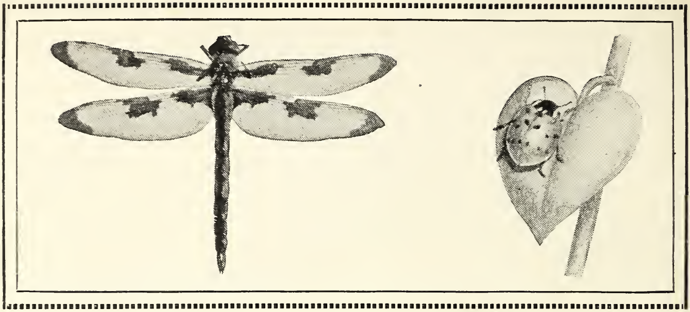
and with their covering form a layer over the branches. These layers are taken off and made into varnish, polish, shellac, and sealing wax, and they are used in making shoe polishes, buttons, and many other things.

3. Insects that are Useful to Man in Other Ways

The dragon fly

Many insects attack, kill, and eat other insects that are harmful to man. They eat those that destroy his crops and his trees. They eat those that suck his blood or poison or annoy him. They eat those that attack his animals.

Have you ever seen a large dragon fly darting here and there through the air? Were you afraid



The dragon fly (left) and a close-up view of a ladybug (right)[1]

of it? People tell all sorts of silly stories about dragon flies. Perhaps you didn't know that the dragon fly you saw was hunting in the air for gnats, flies, and mosquitoes. These insect pests may make our lives very miserable. The dragon fly helps us by catching and eating many of them.

The ladybug

Did you ever hold a ladybug on your hand and say this rime to it?

> "Ladybug, ladybug, fly away home!
> Your house is on fire, your children will burn."

The little ladybug has no house. Its home is wherever it happens to be. It is sometimes called ladybird too. It is really a small beetle. It feeds on plant lice and scale insects. Plant lice and scale insects often kill all kinds of plants.

[1] Ladybug from Linville, Kelly, and Van Cleave's "General Zoology."

American Museum of Natural History

Look closely and you will see many, many ladybugs in this picture

Years ago the people of California had a great deal of trouble with a small scale insect. This scale pest was destroying many of the best fruit trees. So the people brought a special kind of ladybug from Australia to help them get rid of the pest. And the ladybug did help them; in a few years these scale insects had decreased in number.

The praying mantis

It is great fun to see a praying mantis on its knees eating its dinner. It looks as though it were praying. Its front pair of legs are large and strong.

American Museum of Natural History

The praying mantis (left) and the ichneumon fly (right). These two insects eat insects that are harmful to man

They are made for grasping and holding its prey. When a mantis is waiting to catch an insect, it rests on bent knees, with the front legs held up high; then it steals slowly upon the insect and catches it. The mantis eats a great many grasshoppers and other harmful insects. Sometimes it eats insects that are not harmful. The female mantis often eats her mate. Doesn't that seem strange? And she eats him during the mating time!

The ichneumon fly

The ichneumon fly may be found in many parts of North America. It will not live where the climate is very cold. It lays its eggs in the bodies of many different kinds of caterpillars. Some of these caterpillars are the enemies of our fruit and shade trees. When the young ichneumon flies are hatched, they begin to feed upon the bodies of the caterpillars. In this way many of the harmful caterpillars are destroyed.

4. Other Insects that Help

Did you ever watch ants dragging off the dead bodies of insects? Some kinds of beetles will do this too. You have learned how bees carry from their hive the bodies of bees that die. It is interesting to watch these little insects trying to keep places clean. They deserve to be called scavengers.

I once watched some ants dragging the bodies of several mosquitoes away from a window screen. The mosquitoes had been killed in different places on the screen. The ants worked steadily for a long time. When they had finished, not the smallest part of a mosquito was left on the screen.

The garden is a splendid place to find insects. They travel about from flower to flower. Do you know what they are doing? They are getting the nectar from the flowers. But while they are getting the nectar they are also carrying the little pollen grains from blossom to blossom. This helps to make the egg cells in the seeds fertile. Helping to fertilize the flower and fruit seeds is one of the most important ways in which insects help man. Insects are very useful to flowering plants, and the flowering plants are useful to the insects. They help each other. Some insects do more of this work than others. Bees, moths, and butterflies are among the more helpful ones.

Things to Think About

1. We get most of our raw silk from other countries. Why don't we raise enough silkworms to supply our needs?

2. What is the most valuable work that insects do for man?

3. How do insects differ from most other animals?

4. Do you know any useful insects that are not mentioned in this unit? Name them.

Things to Do

1. Some boys and girls raise honeybees successfully. You may like to raise them, too. Ask your teacher to tell you how to do this.

2. Watch a group of ants when they are acting as scavengers.

3. See if you can find some other insects that act as scavengers.

Problem 2 · Insects that are Harmful to Man

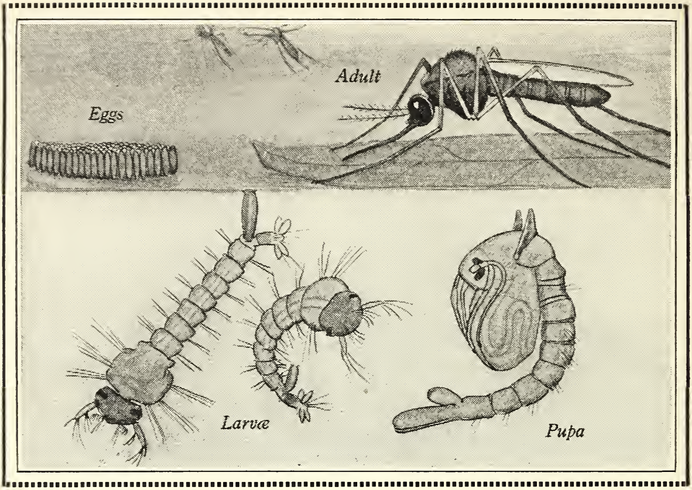
1. Insects that interfere with Man's Health

The mosquito

Have you ever lived in a tent or a house in the summer time without having the windows and doors screened? Were you very comfortable? You may have been annoyed by flies and mosquitoes. These insects are more than a nuisance. They are really very dangerous to our health.

Some scientists think that mosquitoes are the most deadly insect enemy that man has. They will lay their eggs in almost any pool of water. They will even lay eggs in the water that stands in an old tomato can or in an old jar or bottle or in the hollow of an old tree stump. Anywhere that water stands for a week or more is a good place for them to breed — that is, a good place for them to lay their eggs and for their young to hatch.

The mosquito lays its eggs in a flat mass in the water. They hatch very quickly. It is said that eggs laid early in the morning will hatch in the early afternoon of the same day. Do you wonder we have so many mosquitoes? Out of the egg comes the wriggler, or larva. In a short time the larva changes to the pupa. The pupa stays in the



The life story of the mosquito from the egg to the adult insect

water until the adult mosquito is ready to crawl out of the old skin into the air. Most mosquitoes do not fly very far away from their breeding places, but sometimes the wind carries them off.

Certain kinds of mosquitoes are the means of spreading malaria and yellow fever. The germs of these diseases are never in the bodies of the mosquitoes when they are hatched. The mosquitoes pick up the germs when they suck the blood of a person who has the disease. These germs then grow and increase in numbers in the bodies of the mosquitoes. When the mosquitoes suck the blood of healthy persons, some of the germs go

into these persons' bodies. This may help the fever to spread among many people. It is the female mosquito that sucks blood. The male usually prefers the juices of plants. You will be glad to know that the terrible disease yellow fever has been almost destroyed by doctors who made a study of it a number of years ago.

Millions of mosquitoes breed in swampy places every year. People are trying hard to get rid of them by draining the swamps and by pouring oil on the surface of the water in swampy places. Mosquitoes breathe air through a little tube in their bodies, which they stick up out of the water. When there is a covering of oil on the water, the mosquitoes can't raise their breathing tube; so they die.

The mosquito has many enemies. Among them are bats, dragon flies, many kinds of birds, and fish. These animals use the mosquito or its larva for food.

All mosquitoes do not carry fever germs, but all are unpleasant neighbors to have.

The house fly

House flies are as dangerous to man's health as mosquitoes, but in a different way. They breed in filthy places. They lay their eggs in old manure and in garbage piles. The female fly may lay

The house fly. Notice the great number of hairs on the fly's feet and legs. These hairs help him to pick up germs in the dirty places he visits[1]

about five hundred eggs during the summer. One pair of house flies may have millions of grandchildren in one year. The eggs hatch, become larvæ, pass into the quiet, pupa stage, and become adults in about ten days. After a house fly has visited all kinds of dirty places, it may walk over the food on our tables or in our kitchens. Wherever it goes it leaves a trail of bacteria, or germs. Some-

[1] From Linville, Kelly, and Van Cleave's "General Zoology."

times it is called the typhoid fly because it helps in the spread of typhoid germs.

We should try to kill as many flies as we can. The best way to get rid of flies is to leave no breeding places for them. Keeping everything very clean means a great deal in getting rid of them. Because they breed so quickly, one must constantly watch for them. Screens, swatters, and poison fly-papers are a help in this work.

The body louse and the flea

Most of us have never seen a body louse or a flea, but we shudder when we think of them. They are tiny little insects, and they usually mean dirty surroundings, too. They attack the bodies of man and animals, suck their blood, and cause great suffering. Body lice live in the clothing and go upon the skin to feed. Cotton and silk clothing are less apt to contain lice than woolen clothing. Head lice look much like body lice. They are gray and flat. The best way to get rid of them is to clean the body thoroughly. The hair should be cut in bad cases. The clothes should be steamed or fumigated. Bedding should be treated in the same way.

We know today that certain diseases are carried by these body pests. During the World War many cases of typhus and trench fever were caused by these insects.

Fleas bite people as well as dogs, cats, skunks, rats, mice, and many other animals. Fleas carry a disease called bubonic plague. Pets that have fleas should be washed with a good flea soap and warm water. Care should be taken to rinse the animal thoroughly before allowing it to lick its coat. The eyes should be rinsed with clear water immediately. The sleeping places of animals having fleas or the yards where fleas are found should be cleared of litter. A layer of salt may be put on the place, or it may be sprayed with creosote oil.

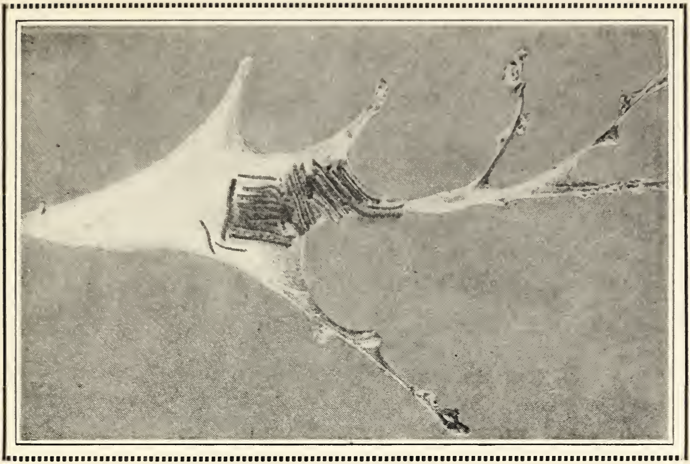
2. Insects that eat Man's Food and his Trees

There are so many different kinds of insects that attack man's food and his trees that we shall not try to call them by name. We shall think of them in these three groups: the boring, the sucking, and the chewing insects.

The larvæ of the boring insects tunnel their way into the stems, trunks, and roots of plants. They work on the inside; so they may do a lot of damage before man knows about it.

Sucking insects are so small that it is not easy to see them. They live on the juices of plants. We find them mostly on the stems and leaves.

Chewing insects form a very large group. Caterpillars are chewing insects; so you may know this



Tent caterpillars in their nests. Where will they get their food?

class best of all. It is easy to see the damage that is done by them, for the leaves soon begin to show that hungry mouths are feeding on them.

Grasshoppers and locusts are chewing insects, too. They destroy a great many plants each year.

Sometimes insects get into the dry foods that we have carefully stored in our closets. They get into cereals. They get into flour. They get into dried peas and beans. They seem to get into everything. Man must take care of his food, or the insects will have the larger part of it.

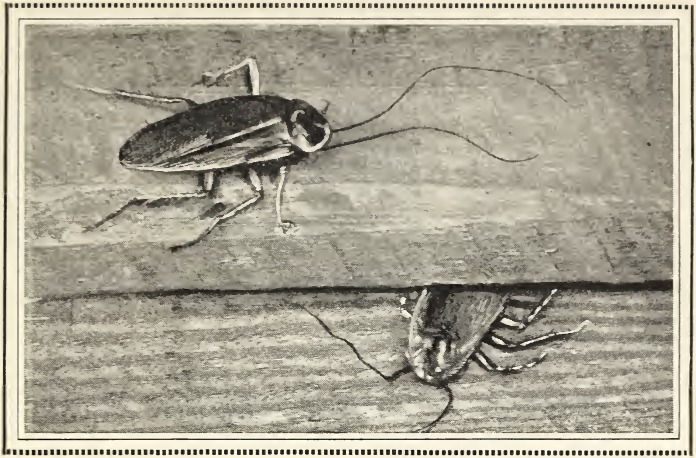
What do you think has happened to the head of cabbage on the left?

3. Insects that are found in Some Homes

The bedbug

The bedbug has been carried by man into almost all parts of the world. At one time the bedbug may have had wings, but it has now lost them. Its little flat body makes it possible for it to live in the narrowest kind of cracks in walls and in beds. It carefully hides its little pile of eggs. Sometimes there are only six eggs, but often there are over fifty eggs in one of these tiny piles. In about eight days the eggs hatch. Bedbugs have a strong odor. This odor often tells us that they are hiding somewhere about the room.

Bedbugs suck the blood not only of man but also of guinea pigs, chickens, mice, horses, and other animals. They are easily carried from place



American Museum of Natural History

Cockroaches. It is not difficult for the roach to crawl under the crack in the wood, for its body is flat

to place, so that it is possible for the cleanest of housekeepers to have them in her house. Mattresses, rugs, and clothing may be cleaned by steaming. Kerosene or gasoline may be put in the cracks of furniture, or the house may be tightly closed and fumigated.

A strange thing about the bedbug is that it can live a long time without food. It is often found living in old lumber camps and houses that have not been used for many months.

The cockroach

The cockroach is another insect pest that is often found in houses. It will eat almost anything.

It has a flat body and can quickly crawl into cracks or under pots and pans and get out of sight. It moves very rapidly; so it is difficult to catch it. Cockroaches seem to prefer hunting about at night. There is nothing much worse than a roach-inhabited kitchen. If corners and out-of-the-way places are kept clean, the cockroaches may disappear. Good roach poisons can be bought to help in getting rid of them.

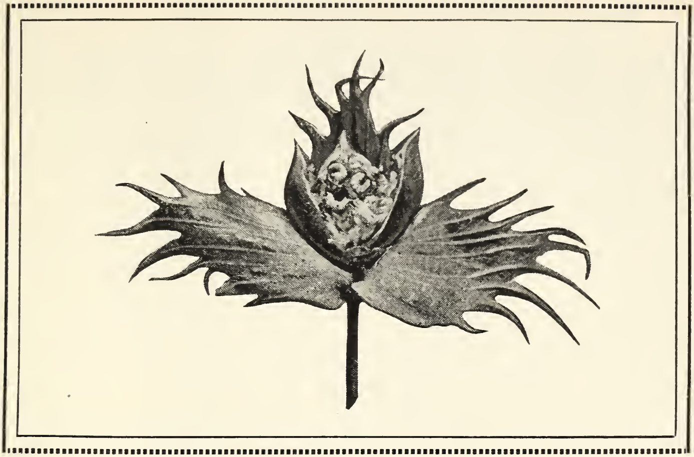
4. Harmful Insects brought to us from Other Countries

Many of the harmful insects that attack our plants and trees were brought into our country from other countries. Can you name any of them?

The boll weevil

You must remember the one that has done so much damage to the cotton crop of our Southern states. It is the boll weevil.

The boll weevil came into the United States from Mexico. It arrived in Texas in 1892 with some cotton plants, and since then has done much harm. The female lays her eggs in the buds or the bolls; so when the larva hatches out, its food is waiting for it in the boll. It takes only twenty-five days for the larvæ to grow up to the adult stage. Then the adult insects mate. One female



The boll weevil, which has done so much damage to our cotton in the South. Find the larvæ in the cotton boll

may lay as many as three hundred eggs during a year. Since there may be ten generations in one year, we can easily see that they multiply very quickly.

In the fall the adult boll weevil may fly as far as thirty to fifty miles away. This is its chief way of finding a new home. When the first heavy frosts come, boll weevils hunt for sheltered places in which to hibernate in the earth or under leaves or in any protected spot. The next spring, from March until June, they may come forth, and then they feed on the young cotton plants. The farmers of the South are trying to get rid of the boll weevil.

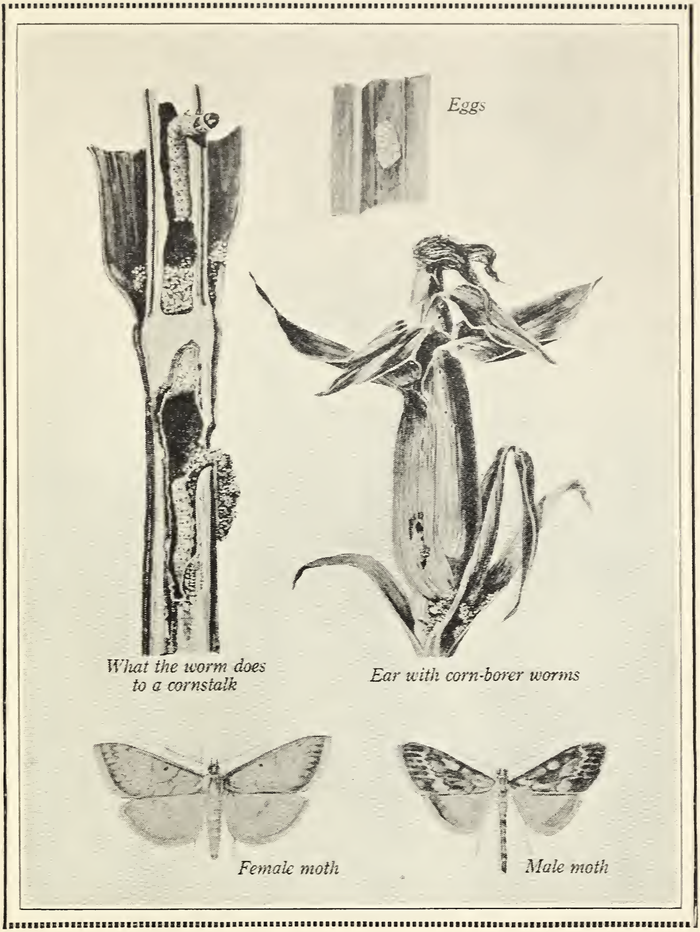
It causes millions of dollars' worth of damage every year because it keeps the flowers and fiber of the cotton from growing. Airplanes are often used to help spray the fields with poison.

The European corn-borer

Some years ago large quantities of broom corn came into the United States from Hungary and Italy. The corn-borer came in with it, and it has now spread over a large part of our corn-growing region. These insects pass the winter as full-grown caterpillars in the stalks of plants; their favorite plant is corn. In the spring they make cocoons and come out as moths. These fly about at night and lay their eggs on the underside of leaves. One moth usually lays about five or six hundred eggs, and there are sometimes two generations in a year. Our government has spent ten million dollars to help the people who are trying to destroy the corn-borer and its eggs.

Scale insects

Some scale insects have been brought to the United States from Australia, China, and other countries. These insects take the life-giving juices of the plants. Thousands of fruit trees and shade trees all over our country have been killed by the San José scale. These tiny insects fasten themselves on the bark of trees and suck the sap. A



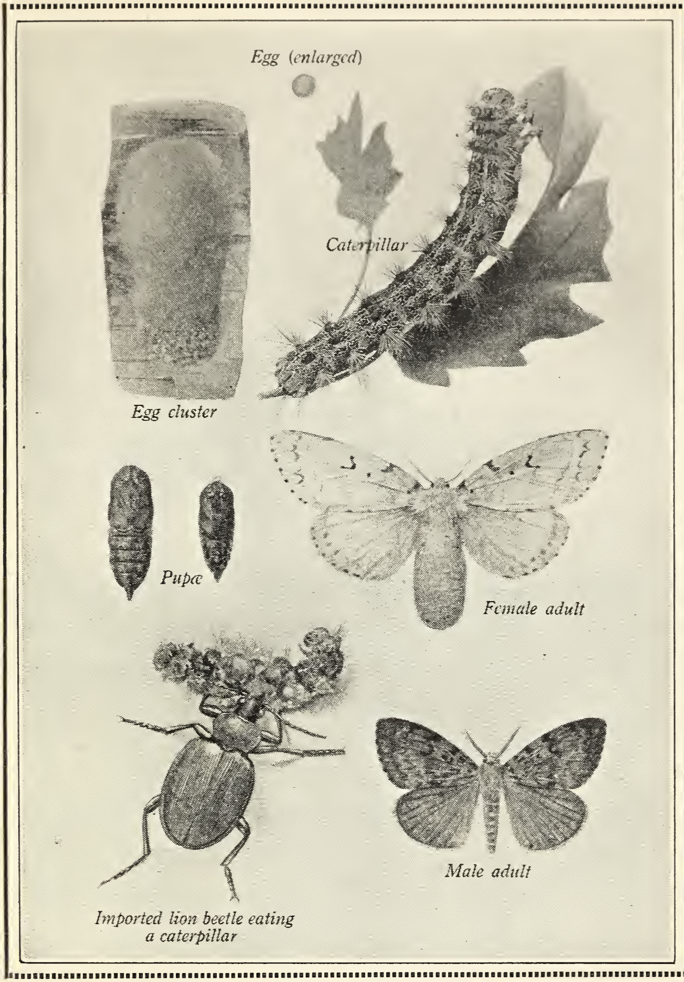
The European corn-borer

waxy substance comes from their bodies which hardens and covers them. This hard covering protects them. Sometimes the bark of trees is covered with them. At such times the tree is likely to die. The San José scale is carried from place to place by birds, insects, and the wind. It is sent to all parts of our country on young trees from nurseries. Ways for getting rid of this pest have been discovered. People need only to watch their trees carefully and to spray them with the right kind of poison.

The gypsy moth

In the year 1869 the gypsy moth was brought to the United States from Europe. Ever since, it has been a terrible enemy of our trees. One day a man was experimenting with the eggs of the silkworm. He had some eggs of the gypsy moth in a box, also. These eggs disappeared, and he could not find them. When the eggs hatched, the gypsy-moth pest was started. He did his best to help destroy the moth, but he was not successful.

Millions of our most beautiful trees have been destroyed by this moth. Large sums of money have been spent every year to help get rid of it. In Europe it has an enemy. This helps the people there to keep the number of gypsy moths small. Within the last twenty years our government has



This picture shows the gypsy moth in its development from the egg to the moth

United States Department of Agriculture

Larvæ of the Japanese beetles in the ground

been bringing parasites, or enemies, of the gypsy moth from European countries. These parasites live in the bodies of the gypsy moths and kill them.

Japanese beetle

The Japanese beetle has become a great pest in the eastern part of our country. It arrived here through Riverton, a city in New Jersey. It is supposed to have come in packages of Japanese iris bulbs that were sent to the United States, and it is rapidly spreading through the eastern part of our country. It will eat almost anything. The small, white larvæ live in the ground.

Japanese beetles on a peach tree

The females of most insects lay hundreds of eggs. The eggs hatch; and, before we know it, the insects are almost everywhere. Wherever a pest occurs it is usually difficult to get rid of it.

Many of the insects that are brought into the United States become dangerous pests. In their home country there is usually some enemy to prey upon and kill them. But in their new home there is nothing to interfere with them; so they increase in numbers very rapidly.

The insects that you have been reading about are not the only ones that have been brought into our country. They are, however, some of the best known because of the great damage they have done.

Many men and women spend their time in observing and studying insects. They find them most interesting. They report the harmful ones and tell us how to get rid of them. They also report the useful ones and tell us how to make use of them.

Things to Think About

1. How is it possible for the different kinds of insects to increase so rapidly in numbers?

2. What is the very best and surest way to get rid of some of the bad insect pests?

3. Name other insects that you know to be harmful.

4. Why is it a good thing to inspect fruits, vegetables, and flowers that are sent from one state to another? that come to us from foreign countries?

5. By studying the rocks of the earth, men have discovered that insects have been on the earth for thousands of years. How can they tell?

6. Explain each of the following:
   - *a.* Man must declare war on those insects that are harmful.
   - *b.* More men and women are needed to study insects.
   - *c.* We should not kill all insects.
   - *d.* Insects that are not harmful in Europe may become very harmful when brought to America.
   - *e.* Birds help us in fighting harmful insects.
   - *f.* Some insects help us in fighting other insects.
   - *g.* It is difficult to keep insects from spreading from one region or district to another.

7. Why do you think insects have been so successful?

8. What is the greatest thing which man has that insects do not have?

Things to Do

1. Destroy the nests or tents of caterpillars that you find on fruit and shade trees. The best time to do this is when the caterpillars are in the nests.

2. Look for the egg cases of tent caterpillars on the twigs in the fall and destroy them.

3. Be careful not to have breeding places for mosquitoes and flies near your home or your summer camp.

4. If you find larvæ in cereal or other dry foods, put some of the food in a glass jar and see what happens.

Key to the Sounds

ă *as in* at	ō *as in* go
ā *as in* ate	ô *as in* horse
ä *as in* arm	oi *as in* oil
ĕ *as in* bet	o͞o *as in* food
ē *as in* be	ŭ *as in* us
ẽ *as in* her	ū *as in* use
ĭ *as in* bit	ŋ *as in* ink
ī *as in* bite	t͟h *as in* bathe
ŏ *as in* got	zh *like the* s *in* pleasure

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